ANNUAL REPORT 1960

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Fort Collins, Colorado — Raymond Price, Director

FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

LOCATION OF FIELD UNITS

RESEARCH CENTERS

Albuquerque, New Mexico
Marron Hall
University of New Mexico

Flagstaff, Arizona
Arizona State College

Fort Collins, Colorado
Braiden Hall
Colorado State University

Grand Junction, Colorado
Post Office Building

Laramie, Wyoming
Agriculture Building
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
South Dakota School of Mines and Technology

Tempe, Arizona
Agriculture Building
Arizona State College

Tucson, Arizona
University of Arizona

RESEARCH LABORATORIES

Forest Diseases:

Albuquerque, New Mexico
New Federal Building

Fort Collins, Colorado
South Hall
Colorado State University

Forest Insects:

Albuquerque, New Mexico
New Federal Building

Fort Collins, Colorado
South Hall
Colorado State University

ANNUAL REPORT

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

CALENDAR YEAR 1960

The Station maintains central headquarters at Fort Collins, Colorado, in cooperation with Colorado State University

(Not for publication)

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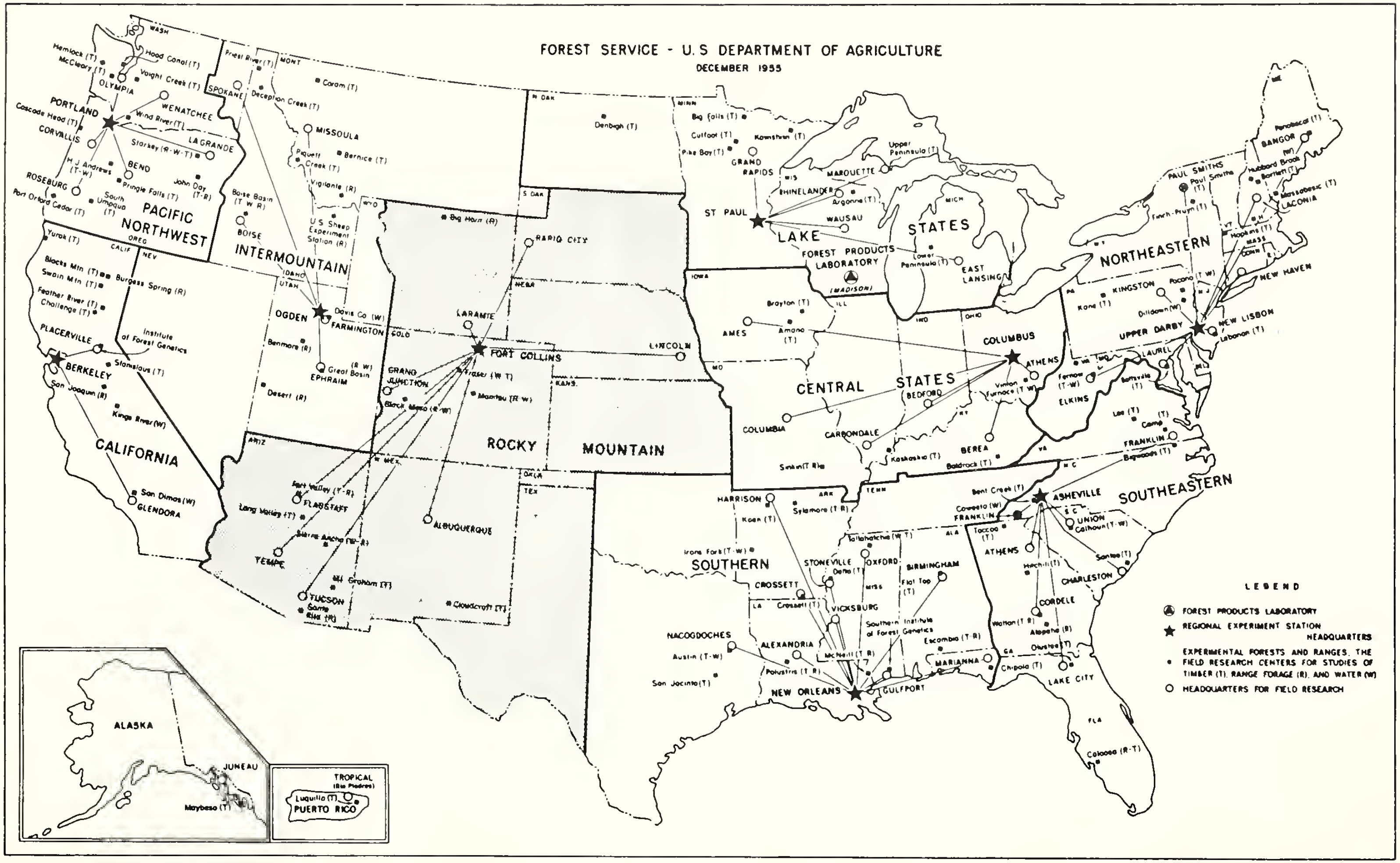
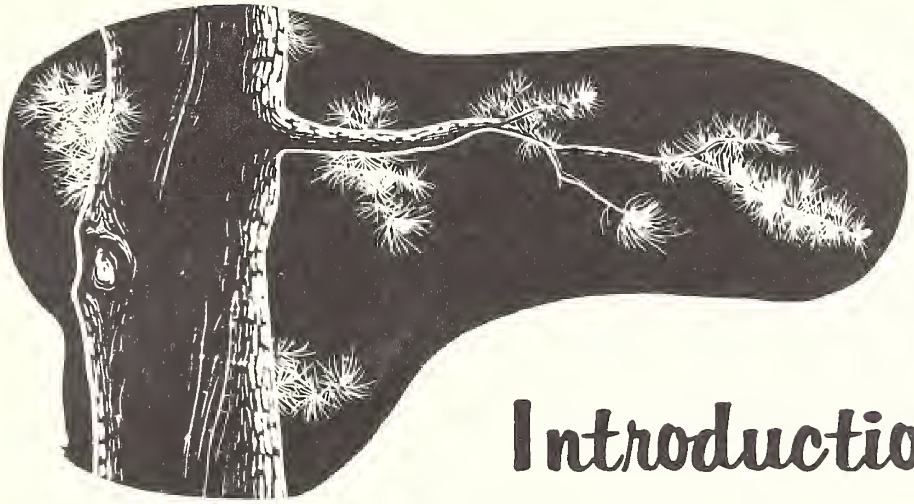


Location of the forest and range experiment stations and the Forest Products Laboratory



Introduction

Multiple-use management of forest and associated rangelands to meet the impact of an enlarging population is a challenge to forestry research. To meet these greater demands, we need more information about resource requirements and possible uses.

Forestry scientists in the Rocky Mountain region are already probing into many of these problems that relate to the protection, management, and better use of forest lands. Some of the highlights of this research during 1960 include the following:

Forest insect research has made progress in finding better ways to prevent losses caused by the Engelmann spruce beetle. Use of helicopters has made possible the early detection of outbreaks in remote spruce forests. Chemicals, trap-trees, and improved logging methods are being used to prevent and suppress these outbreaks. Current research, however, is centered on chemical controls and on the natural factors that limit beetle populations.

Forest disease research continues to show that dwarfmistletoes and heart rots are the major disease problems. Studies in Colorado have revealed that badly infected lodgepole pine will never produce a satisfactory timber crop. Other studies in lodgepole pine indicate that epidemics of tumors, a little known disease, may cause serious losses in some stands in northern Wyoming. New information on the relation of decay to age of subalpine fir in Colorado and of ponderosa pine in New Mexico should lead to improved management practices for these types. Preliminary greenhouse experiments have suggested that the alternate host of the damaging spruce broom rust may be bearberry (kinnikinnik) instead of chickweed as previously assumed.

Forest management research has found that artificial seeding of Engelmann spruce and lodgepole pine holds little promise at high elevations on the White River Plateau in Colorado. In contrast, natural reproduction of Engelmann spruce on the Fraser Experimental Forest was excellent following three

methods of cutting. Natural reproduction of ponderosa pine in Arizona depends on early summer germination to assure satisfactory survival. Browsing of pine seedlings by deer in Arizona was also reduced greatly by applying repellents. In the Black Hills of South Dakota, future diameters, basal areas, and volumes of immature stands of ponderosa pine can be estimated from an inventory of the present stand and site index. Also, site index for ponderosa pine can now be rated in Plains windbreaks.

A significant advance in forest utilization in the central Rockies was the establishment of markets for pulpwood, including sawmill residue and roundwood. Pulp chips were produced in the Black Hills for the first time. In northern Arizona a pulp and paper mill is under construction.

In range management and wildlife habitat research, preliminary results on mountain grassland range in Wyoming indicate that cattle distribution improves, the plants benefit, and steers make better gains when rotation grazing is practiced. Production of crested wheatgrass grazed in the spring in New Mexico was not curtailed by grazing intensities up to 70 percent. In Arizona, it was found that increases in perennial grasses after shrubs were removed were much greater on soils derived from quartzite than on soils derived from diabase rock. Also, mesquite invasion on the Santa Rita Experimental Range has been more pronounced on sandy soils than on clay soils. Two applications of 2,4,5-T to mesquite-infested ranges, followed by seeding with Lehmann lovegrass, more than repaid the treatment cost in 3 years through increased forage production. In Colorado, healthy Thurber fescue ranges sprayed with 2,4-D more than doubled in herbage production the year following treatment.

Watershed management research reports some physical features of snowpacks, which relate to avalanche control, reforestation, and management for water yield. Measurements taken in an alpine snowpack showed that creep (downslope motion) averaged 1 inch per foot of snow and settlement (shrinkage of the snow) was 2.5 inches for every foot of snow depth. Daily evaporation from snow in Arizona and New Mexico under aspen and pine stands varied between 0.006 and 0.016 inch.

On a chaparral watershed near Roosevelt, Arizona, after fire had completely destroyed the plant cover, heavy rains caused high sediment yields. More than 39,000 tons of sediment per square mile have moved from this watershed. Other studies in the semidesert shrub type have shown that intensive site treatments such as grubbing shrubs, sloping gully banks, mulching the soil surface, and seeding to grass can reduce sediment yields to about 20 tons per square mile.

New knowledge gained from research on the life cycle of tamarisk (saltcedar) will aid in control measures. The distribution of the tiny seeds is mainly by water. Seedlings are delicate in their first weeks and easily killed by lack of moisture or by inundation. Fluctuating water levels can be used to prevent new establishment. Cut stems sprout vigorously but roots do not sprout. Therefore, thorough root plowing is effective.

Details of these highlights as well as other recent findings are presented in the following pages. Detailed accounts of our research results are released through numerous publications. An annotated list of publications issued in 1960 is included in the bibliography at the end of this report.

Forest Insect Research

Spring generation of Arizona five-spined engraver dependent upon dead host material

The Arizona five-spined engraver has three generations a year. The spring (first) generation is produced by overwintering adults and mortality is heavy. These adults are largely dependent upon slash and dying ponderosa pine for host material. In 1960, the number of new adults produced by this first generation was only 4.7 per square foot of bark compared with 55.1 and 48.9 by the second and third generations, respectively. The second and third generations were also more aggressive. They infested and killed pole-sized ponderosa pine and tops of larger trees. Destruction of spring slash and removal of dying trees should lessen the chances of mid- and late-season buildup of an epidemic beetle population.

Bacterial pathogen tested for control of Great Basin tent caterpillar

Noteworthy effects of Thuricide, a commercially available bacterial pathogen of insects, were produced upon three-fourths grown larvae of the Great Basin tent caterpillar. Heavily infested aspen sprayed with a water suspension of this micro-organism exhibited little or no change in amount of defoliation 20 days later and after the caterpillars had pupated. Untreated check trees continued to be fed upon, and defoliation increased from about 50 percent to more than 95 percent. Density of pupae on the treated and untreated trees was not significantly different, but the mean weight of the

pupae on the treated trees was about 20 percent less. Water suspensions of Thuricide (30 billion viable spores of Bacillus thuringrensis per gram) were used at dosages of 0.9, 1.8, and 3.6 grams per gallon of water. The mode of action of the pathogen and the significance of the findings are yet to be determined.

Flight mill used to study Engelmann spruce beetles

Engelmann spruce beetles were attached to the end of a rotating arm to study their flight habits and flight endurance, particularly as influenced by a tagging material and by parasitic nematodes. See figures I-1 through I-5 for details of apparatus and techniques.

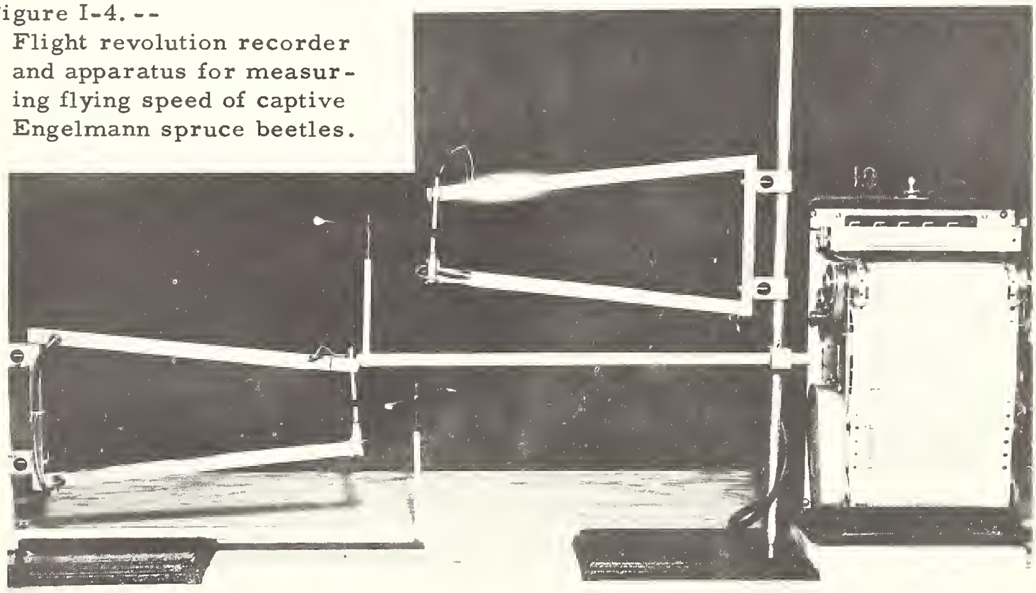
Figure I-1. -- A test beetle poised for a speed and endurance flight. A piece of foil and some wax connects the pronotum to the arm.

Figure I-2. -- Dorsal view of foil attachment to pronotum, and the typical preflight position of the wings.

Figure I-3. -- Posterior wings fully unfolded. The white areas inside and down near the base of the elytrum are clusters of nematodes (Diplogaster pinicola Thorne).

Uninterrupted flights of more than 1 hour were uncommon; however, one specimen flew 7.4 miles nonstop in 4 hours. The general conclusions were that tagging with radioactive isotopes caused the beetles to fly faster initially but had no effect on their endurance. No effect of parasitic nematodes could be demonstrated because of the wide range in individual beetle performances of flight speed and endurance.

Figure I-4. --Flight revolution recorder and apparatus for measuring flying speed of captive Engelmann spruce beetles.



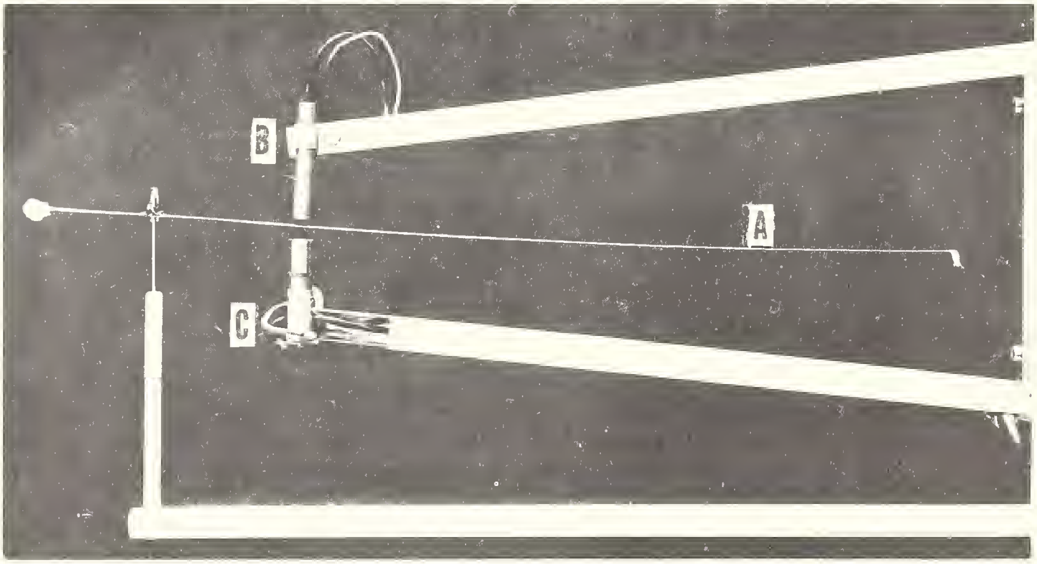


Figure I-5. --Closeup of flight apparatus: A, flight arm; B, photoelectric cell; C, lamp for light beam. Arm is balanced on needle at the glass bearing. A captive beetle hangs by the pronotum at the end of the arm. The end is 12-5/8 inches from the needle, so at each revolution the beetle will have flown a tenth of a chain.

Preparation of ethylene dibromide emulsifiable concentrates for bark beetle control

An ethylene dibromide concentrate for bark beetle control must have certain emulsifiable properties to be fully effective. Rigid specifications cannot be prepared to cover all conditions because of the wide variations in temperature, properties of fuel oils, hardness of water, and elapse of time between mixing with water and application. A satisfactory concentrate is one that mixes quickly and uniformly with little agitation and under field conditions where the water is often cold and sometimes hard, is stable and the ethylene dibromide will not cream down in less than 24 hours, and can be reemulsified with agitation after creaming has occurred. New and improved emulsifiers are constantly being added to the market. Only a few have been screened for use in the central and southern Rocky Mountains for bark beetle control. The first ethylene dibromide formulation developed for use in Colorado contained 8 ounces of emulsifier composed of a blend of three parts Triton X-100 and five parts Triton B1956 per gallon of concentrate. This may still be one of the best emulsifiers for areas with hard water. Under most conditions a blend of one part Triton X-151 to five parts of Triton X-171 is more suitable. Other emulsifiers undoubtedly are equally satisfactory, but they should be tested under local conditions.

Corrosion inhibitor increases storage life of emulsifiable ethylene dibromide

The addition of 5 pounds of epichlorohydrin to each 100 gallons of emulsifiable ethylene dibromide concentrate used for bark beetle control greatly lengthens its storage life. Without this inhibitor the ethylene dibromide corrodes metal containers, and the emulsifiable properties often are reduced after storage for 1 year. Hence, the insecticide could not be carried over from 1 season to the next. In one series of storage tests started in 1952 with epichlorohydrin, no metal corrosion was visible after 7 years. Emulsifiable properties were equal to fresh mixtures. Epichlorohydrin sells for about 40 cents a pound. A formulation to make 100 gallons of emulsifiable ethylene dibromide concentrate that has proved to be successful for Engelmann spruce beetle control is:

Ethylene dibromide	300 pounds
Triton X-151	9 pounds
Triton X-171	44 pounds
Epichlorohydrin	5 pounds
Fuel oil No. 2 to make 100 gallons	525 pounds

For the control of the Black Hills beetle, Douglas-fir beetle, and bark beetles other than the Engelmann spruce beetle, 200 pounds of ethylene dibromide can be used in the formula.

Progress with tests of systemic insecticides

The European elm scale (Ericoccus spurius Modeer) and American elm were used as a test insect and test tree to screen systemic insecticides for further testing against bark beetles. The material was poured into auger holes in the stem (trunk implantations), drenched around root collar, and mixed in top soil around root collar. A systemic insecticide is a chemical that can be introduced into the sap stream of a plant and carried to the site of insect feeding in concentrates that are toxic to the insects but nontoxic to the plant. A summary of the findings is as follows:

Method and chemical	Dosage for a 12-inch tree (Ounces)	Scales killed (Percent)
Trunk implantation:		
Dimefox (50 percent solution)	1.4	99
Phosdrin (10.2 percent solution)	8.0	99
Phorate (14.2 percent solution)	8.0	45
Drench around root collar:		
Dimefox (1 percent solution)	80.0	29
Dimefox (1 percent solution)	160.0	43
Phorate (1 percent solution)	160.0	25
Phosdrin (1 percent solution)	160.0	40
Demeton (1 percent solution)	160.0	23
Granules mixed into soil:		
Di-syston (10 percent granules)	53.7	18
Phorate (8 percent granules)	67.1	0

The tests demonstrate that trunk implantation of two materials gives adequate conduction and control of the scale. Similar quantities of the same materials are less effective when applied as dilute solutions or as granules to the soil at the root crown.

Spruce cull must be manipulated to prevent Engelmann spruce beetle outbreaks

Spruce cull resulting from logging is a positive threat to residual spruce stands because it provides favorable breeding grounds for the Engelmann spruce beetle. The cull can be used as traps to absorb native and invading beetles. Following infestation, but before the new generation of insects has matured, the cull can be treated to destroy the brood. This may be done by burning or spraying with insecticide. The manipulation may be tree-length logging so as to pile the tops and cull at central points for burning, by windrowing infested cull with slash

and then burning, by distributing the cull and larger limbs so that each infested piece may be sprayed with ethylene dibromide, or by broadcast burning the slash and cull. It is essential, of course, that these treatments be carried out after beetle flight but before the new generation emerges.

Engelmann spruce beetle control by preventive measures

As more and more of the Engelmann spruce stands in the central Rocky Mountains are harvested, the potentialities of population explosions of the Engelmann spruce beetle become more evident. The resident beetle populations in the overmature stands persist at high endemic levels. Road construction and logging favor beetle development more than anticipated. The consequence can be extensive losses of timber in the residual stands unless certain measures are followed.

The following facts confront the management of overmature spruce stands:

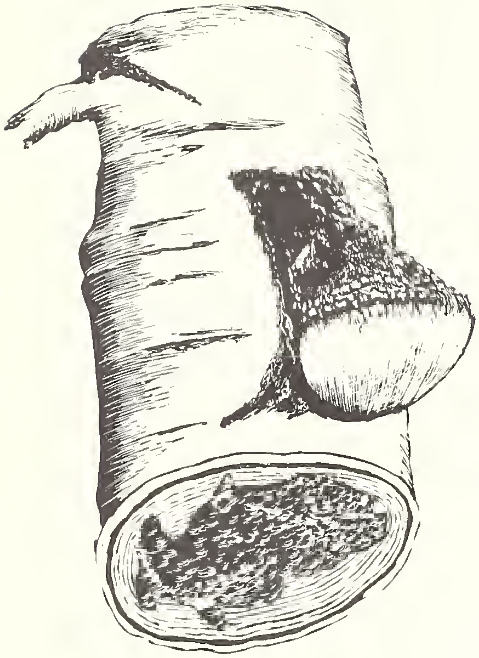
1. The annual loss of high-volume spruce trees to the spruce beetle and blowdown results in little or no net growth.
2. The beetle population is kept at a high endemic level because of high survival of brood in the wind-felled spruce, where they are protected by snow cover from low temperatures and feeding by woodpeckers.
3. When the stands are opened by road construction, the down spruce on the right-of-way serves as favorable host material.
4. As logging progresses, a large volume of cull is left behind. This cull generally can absorb the increased numbers of beetles produced as a result of road construction and logging.
5. Upon termination of logging, or even before, and when the cull becomes saturated, the beetles infest green spruce in leave areas or in other neighboring stands.

Guides that can be followed to prevent spruce beetle outbreaks in logging areas are:

1. After the cull becomes infested, it should be burned or sprayed with ethylene dibromide emulsion.
2. Use logging practices that cause the minimum amount of blowdown.
3. Use trap trees where practical to absorb the beetles from cull and blowdowns.
4. Scout neighboring spruce stands within 20 chains for beetle-infested trees.
5. Insist that all logging practices prescribed to allay outbreaks are carried out correctly and at the right time.

Infestations resulting from road construction and logging can be controlled by:

1. Logging infested trees from the leave areas, selectively or by clear cutting,
2. Making new but unscheduled sales of infested blocks,
3. Applying insecticides,
4. Using trap trees.



Forest Disease Research

DWARFMISTLETOES

Badly infected lodgepole pine stands will never produce a crop

Comparisons between healthy and infected parts of the same lodgepole pine stands in several national forests in Colorado indicate that the important factors affecting growth are the intensity and duration of infection. If a stand is infected throughout its life, little or no merchantable volume can be expected (fig. D-1).

Dwarfmistletoe endophytic system found only short distance beyond outward evidence of infection

In a laboratory study of 36 artificially infected branches of ponderosa pine, ray-like sinkers of southwestern dwarfmistletoe (*Arceuthobium vaginatum*) were found in the wood as far as 7.2 cm. beyond any evidence of swelling and a maximum of 8.1 cm. beyond the nearest shoots of the parasite. Neither age of host tissues when inoculated nor sex of the dwarfmistletoe plant had any significant effect on lateral extension. The annual rate of this extension of the endophytic system averaged 1.0 cm. in each direction.

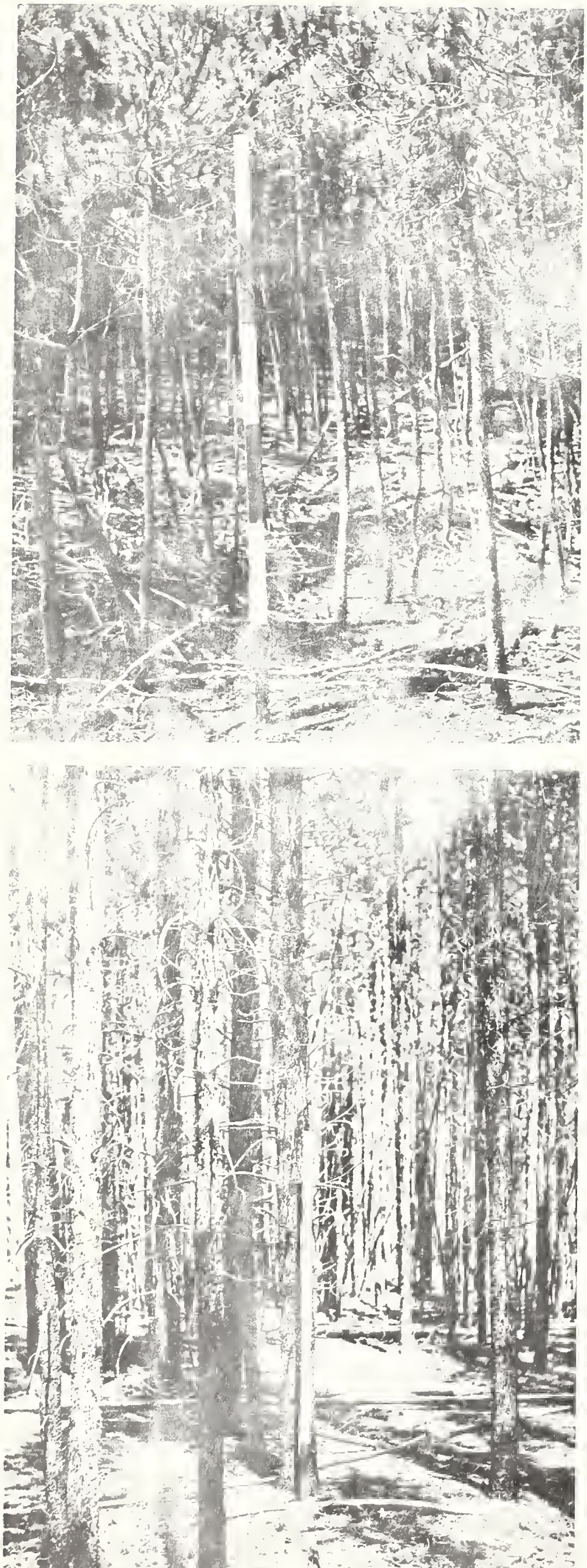


Figure D-1.--An 85-year-old lodgepole pine stand on the Roosevelt National Forest in Colorado.

A, Severely diseased part of the stand. These trees have been subjected to dwarfmistletoe infection throughout their lives. Dominant and codominant trees averaged 14 feet in height and 2.1 inches in d.b.h.

B, Healthy part of the same stand. Dominant and codominant trees averaged 36 feet in height and 5.2 inches in d.b.h.

New records for lodgepole pine dwarfmistletoe

Lodgepole pine dwarfmistletoe (*Arceuthobium americanum*) was found for the first time on Engelmann spruce. A spruce tree in a mixed lodgepole pine-Engelmann spruce stand on the Roosevelt National Forest, Colorado, was heavily infected and appeared to be as susceptible as the adjacent lodgepole pines.

A fungus parasite (*Septogloeum gillii*) was found on lodgepole pine dwarfmistletoe (*Arceuthobium americanum*) in the Williams Fork area of the Arapaho National Forest, Colorado. There was considerable damage to dwarfmistletoe shoots in this one locality. This is the first finding of the disease in the central Rocky Mountain area, although it has been reported on *A. americanum* in Montana.

Extent of recleaning operation determined for Whitetail Dwarfmistletoe Control Unit

According to a random plot cruise, about 160,000 ponderosa pines are infected with dwarfmistletoe in the 12,000-acre Whitetail Dwarfmistletoe Control Unit of the Mescalero-Apache Reservation in New Mexico. This number is estimated to be about 35 percent as many as were removed during the original control operation in fiscal years 1953-55. About 25 percent of the infected trees can be freed of visible dwarfmistletoe by pruning as compared with an estimated 4 percent in the initial treatment.

Distribution of the random plots suggested that direct control had been applied originally on about 47 percent of the net area. However, rouging was moderate to severe on only 27 percent of the area; on 20 percent it was light to negligible.

Dwarfmistletoe infection was observed on 79 percent of the plots in stands where direct control had been severe, 33 percent where it had been moderate, and in 19 percent of the plots where it had been light or negligible. The parasite was present on only 8 percent of the plots in stands where control measures were not applied originally.

In general, infection was least severe in the area covered in fiscal year 1953 and most severe in the 1955 work area. This was because dwarfmistletoe infection was not uniformly distributed throughout the control unit. Instead it occurred in three well-defined large centers that covered only 45 percent of the 1953 area but 87 percent of the 1955 area.

This is the only pilot test of dwarfmistletoe control in the Southwestern Region. It has led to the development of useful guides for control in other localities. However, its full value will not be realized until all phases of the initial treatment have been completed.

STEM CANKERS
(including rusts)

Mortality and heart rot are associated with spruce broom rust

Peridermium coloradense causes yellow witches' brooms in three spruce species throughout the Rocky Mountains. Brooms were found to be significantly more abundant on dead trees than on living ones--that is, in some way they are associated with mortality. Also, dead brooms are associated with heart rot in living trees. Clustered brooms in a tree were found in some instances to have resulted from systemic growth of the rust through apparently healthy stems rather than from separate infections.

Alternate host of spruce broom rust may be bearberry (kinnikinnik)

Greenhouse inoculations, not yet fully confirmed, suggest that the alternate host of spruce broom rust is bearberry or kinnikinnik (Arctostaphylos uva-ursi) although chickweeds (Cerastium) have previously been reported as hosts.

Cytospora canker found on Douglas-fir in Mesa Verde National Park

Cytospora canker, caused by Cytospora kunzei, was responsible for top-killing and mortality to Douglas-fir in Mesa Verde National Park in southwestern Colorado. The canker killed the upper 3 to 30 feet of the trees, and the lower boles were colonized by secondary bark beetles. However, some trees appeared to be killed exclusively by the disease.

The only other known outbreak of Cytospora canker on Douglas-fir was along the front ranges in the vicinity of Sedalia, Colorado, in the 1930's. The disease is now inactive in that area.

Sooty-bark canker of aspen is widespread in New Mexico and Arizona

During 1960 sooty-bark canker of aspen caused by Cenangium singulare was found in a number of new localities in New Mexico, and its range was extended to Arizona. The canker was collected in the Capitan and Ruidoso Districts of the Lincoln National Forest, the Sandia District of the Cibola, and the Las Vegas and Jemez Districts of the Santa Fe. In Arizona it was found on the Flagstaff District of the Coconino National Forest and on the Williams District of the Kaibab.

The role of sooty-bark canker in widespread aspen mortality in New Mexico has not been determined. The situation is confused by a number of canker organisms that are endemic in aspen stands. Furthermore, discovery of hypoxylon canker near Tres Ritos, New Mexico, suggests it may be more widely distributed and more damaging in the Southwest than was supposed earlier.

FOLIAGE DISEASES

Needle cast of ponderosa pine is persisting in Southwestern Region

Needle discoloration (fig. D-2) was apparent in the same areas on the Coconino and Prescott National Forests in Arizona where needle cast has persisted for a number of years. Aerial observations indicated that the disease was attacking more pole stands on the Coconino than could have been estimated from roadside observations. Discoloration was recognizable from the air in and adjacent to the original infection center west of Mormon Lake, and it extended about 20 miles southward in numerous shallow draws. Although needle cast was not obvious in the old infection center near Hassayampa Lake on the Prescott National Forest, a pocket of severe discoloration was found again this year at the periphery of the center. A moderate outbreak of the disease attacked all size classes of trees on the Mescalero-Apache Reservation in New Mexico.

A, Appearance of saplings and poles in infection center where disease has persisted since 1956. Coconino National Forest, Arizona.

B, Comparison of foliage from (1) healthy tree, (2) moderately affected tree, and (3) severely affected tree. Prescott National Forest, Arizona.

Figure D-2.--Needle cast of ponderosa pine.

Elytroderma needle blight in Black Hills

Needle blight due to the fungus, Elytroderma deformans, was observed to be causing growth losses in Black Hills ponderosa pine. The disease probably occurs throughout the Black Hills National Forest, but scattered stands on the Wyoming side (Spearfish District) seemed to have the greatest numbers of affected trees this season. Thin crowns and decreased annual increment result from repeated attacks by the fungus. Long-infected trees develop tight witches' brooms, which are common in all districts of the forest. Mortality caused directly by Elytroderma was not observed this year.

STAINS -- DECAYS -- ROOT ROTS

Irregular decay-age relationship found in subalpine fir in Colorado

Decay volume in merchantable subalpine fir larger than 9.5 inches d.b.h. was 35 percent on a board-foot basis and 10 percent in cubic feet. There was an irregular relationship between decay and age. Decay increased with age to a peak in the 150- to 200-year age class, then declined with age to a minimum in the 250- to 300-year class, and then increased again with advancing age to a second peak in the 350- to 400-year age class. The decline in decay after 200 years may be due to the death (possibly through wind breakage or windthrow) of the more decadent trees. No relationship was found between the amount of decay and site quality.

The fungi associated with about 58 percent of the decay volume in subalpine fir were identified. In all, 18 decay fungi were isolated, 6 from trunk rots and 12 from butt rots. Stereum sanguinolentum was associated with 77 percent of the trunk rot volume as compared with only 15 percent for Fomes pini. Three fungi were about equally important causes of butt rot.

None of the decay fungi regularly fruit on living trees, and no consistent external indicators of decay were found. However, broken tops and trunk wounds were usually indicative of extensive decay.

Red-rot losses lower in Chuska Mountains than on Defiance Plateau

Red rot, caused by Polyporus anceps, was present in 35 percent of the trees on the Chuska-Tsailee plots as compared with 34 percent of trees studied on the Defiance Plateau in New Mexico (fig. D-3).

Preliminary analysis of the Chuska-Tsailee data indicates coefficients of variation of 11 percent for gross merchantable volumes and 22 percent for the red rot volumes deducted by U. S. Bureau of Indian Affairs timber scalers. Deductions for red rot amounted to 12 percent of the gross scale on the completed plots. The comparable percentage for the Defiance Unit sample was 15.

A, After study tree has been felled and bucked into sawlogs, the logs are scaled and then marked for cutting into 4-foot bolts.

B, U. S. Bureau of Indian Affairs scaler measures rot showing on end of 4-foot bolt.

C, Splitting a bolt to expose red rot.

D, Red rot in split half bolt.

Figure D-3. --Field work on the defect study on the Navajo Indian Reservation in New Mexico.

Although it is too early to conclude that differences between the logging units are significant, one explanation for the lower red rot volume in the incomplete Chuska-Tsailee sample is apparent: about one-fourth of the gross volume was in relatively sound young trees (Keen Age Classes I and II); whereas such trees accounted for only 10 percent of the gross volume on the Defiance Unit plots. Furthermore, only 43 percent of the Chuska-Tsailee volume was in decay-prone mature or overmature trees (Keen Age Class IV), as compared with 68 percent on the Defiance Plateau.

Root rot damage continues in young lodgepole pine

Root rot caused by Armillaria mellea continued to damage young lodgepole pines on the Roosevelt National Forest, Colorado. In 1960 root rot killed 97 trees in 65 permanently marked infection centers in a 15-year-old stand. On this basis it is estimated that 2 percent of the trees in the stand were killed in 1960, thus bringing the cumulative mortality to about 8 percent.

NURSERY DISEASES

Phomopsis-blighted eastern redcedar planting stock did not survive as well as healthy stock

Blight of eastern redcedar caused by Phomopsis juniperovora frequently causes heavy losses in nurseries on the Great Plains. Blighted nursery stock is commonly distributed for planting because it is believed that it overcomes the effects of the pathogen and develops satisfactorily in the field. To test this view, 300 blighted and 300 nonblighted 2-0 eastern redcedar seedlings were outplanted in eastern Nebraska in the spring of 1959 and will be examined annually for the next 4 years. Survival in December 1959 was 87 percent for nonblighted and 76 percent for blighted trees.

Necrotic ring spot virus is not major factor in plum tree deterioration

Tests have been made to determine whether necrotic ring spot virus is associated with the deterioration of plums in Great Plains windbreaks. In the tests, buds from each suspect tree were grafted to two necrotic ring spot virus-free seedlings of the susceptible Nanking cherry (Prunus tomentosa). If the seedlings did not show typical symptoms within 6 weeks after grafting, the suspect tree was considered to be free of the virus. The following were tested:

American plum (Prunus americana)
- 120 trees in eastern Nebraska (20 from each of 6 windbreaks)
- 40 trees in four native stands in eastern Nebraska
- 60 trees in North Dakota (20 from each of 3 windbreaks)
- 60 trees in Kansas (20 from each of 3 windbreaks)
- 60 seedlings (planting stock in storage at an eastern Nebraska nursery)

Chickasaw plum (Prunus angustifolia)
60 trees in Oklahoma (20 from each of 3 windbreaks)

Only one tree of all those tested, an American plum located in a Nebraska windbreak, contained necrotic ring spot virus.

OTHER DISEASES

Conifer tumors epidemic in some northern Wyoming stands

Galls and burls of unknown cause (often associated with mechanical injuries) occur on occasional trees throughout conifer forests, but in certain lodgepole pine stands, distinctive tumors deform trunks and branches on 60 to 100 percent of the trees. The swellings, which resemble those on spruce in Maine and in western Canada, vary from pea sized to 3 feet in diameter on a 6-inch stem (fig. D-4). Although they cause little mortality, heavily tumored trunks are worthless for lumber, posts, or poles. They seriously impair the productivity of some stands in northern Wyoming, where it was noted that 60 percent of the lodgepole pines had tumors.

Cause of the tumors is unknown. Dwarfmistletoes and fungi are not associated with the disease, and a genetic basis seems remote because limber pine and subalpine fir are frequently tumored where they occur with badly infected lodgepole.

Figure D-4. --
Tumored lodgepole pine on the Shoshone National Forest in Wyoming.

Winter injury common on the eastern slope in Colorado and Wyoming

Physiological needle brooming was common in 1960 on lodgepole pine along the eastern slope of the Rockies in the Roosevelt National Forest, Colorado, and the Medicine Bow National Forest, Wyoming. This type of winter injury is presumably induced by drying winds, which evaporate moisture from the needles faster than it can be replaced from frozen or near-frozen soil. Although most of the foliage was killed in areas where the damage was severe, little direct mortality is anticipated since the buds were still alive on all trees examined. Ponderosa and limber pines were usually not damaged even though they grew intermixed with severely damaged lodgepole pines. Winter injury to Douglas-fir was noticed in a few localities in Colorado. In the vicinity of Redfeather Lakes, Colorado, the damage to Douglas-fir was not obvious until late summer of 1960, although lodgepole pines in the vicinity were severely browned in the spring.

Brooming of narrowleaf cottonwood and aspen may result from winter injury

Brooming of narrowleaf cottonwood and aspen was widespread along the eastern slope of the Rockies in Colorado and Wyoming (fig. D-5). In general, the areas of brooming coincided with areas of winter injury to lodgepole pine. The cause of these brooms has not been definitely determined. Superficially, they resembled brooms of parasitic origin, but it is suspected that they are regrowths following killing of the original branches by severe spring frost. Brooms on both species are characterized by unusually large leaves. For example, leaves up to 7 inches long were found on aspen brooms; normal aspen leaves are only 2 to 3 inches long. Similar brooms have been reported in aspen in Canada, and they too are suspected to be of climatic origin.

Figure D-5. --Brooming of narrowleaf cottonwood apparently the result of frost damage. Livermore area, Larimer County, Colorado.

Forest Management & Forest Fire Research

Spruce and fir reproduce abundantly following three methods of cutting

Excellent reproduction has followed three methods of cutting in old-growth Engelmann spruce-subalpine fir on the Fraser Experimental Forest.

Sixty percent of merchantable volume (trees 9.6 inches d.b.h. and larger) was removed from three 8-acre plots in 1944 as follows:

1. Clear cutting in alternate strips: 50 percent of the plot was clear cut in alternate strips 66 feet wide. Ten percent of the remaining volume was removed from uncut strips in an improvement cut.

2. Clear cutting in small groups: 50 percent of the plot was clear cut in circular patches 66 feet in diameter. Ten percent of the remaining volume was removed from uncut areas in an improvement cut.

3. Single-tree selection: 60 percent of the plot volume was removed by single-tree selection applied uniformly over the whole plot.

Advanced reproduction 3.5 inches d.b.h. and smaller was abundant before logging. Advanced reproduction was dominated, however, by the shade-tolerant fir (table F-1).

Advanced reproduction was also well distributed. From 42 to 64 percent of milacre plots were stocked with advanced spruce and 93 to 98 percent were stocked with all species (table F-2).

Logging with horses destroyed 44 percent of the advanced reproduction on the group clear-cutting plot, 56 percent on the selection plot, and 60 percent on

Table F-1.--Number of seedlings and saplings per acre before logging and up to 15 years after logging

Method of cutting and species	1944 Before logging	1944 After logging	1949	1959
	- - - -	Number	- - - -	
Alternate-strip clear cutting:				
Spruce	906	505	983	7,029
Fir	4,675	1,745	2,155	3,776
Total[1]	5,587	2,254	3,268	11,261
Small-group clear cutting:				
Spruce	1,688	1,127	2,211	4,079
Fir	5,156	2,745	3,755	4,154
Total[1]	6,850	3,876	5,987	8,264
Single-tree selection:				
Spruce	3,081	1,411	2,527	3,736
Fir	3,494	1,482	2,518	2,919
Total[1]	6,594	2,909	5,173	6,843

[1] Includes small numbers of lodgepole pines.

Table F-2.--Percent of milacres stocked before logging and up to 15 years after logging

Method of cutting and species	1944 Before logging	1944 After logging	1949	1959
	- - - -	Percent	- - - -	
Alternate-strip clear cutting:				
Spruce	42	22	29	69
Fir	94	51	54	82
Total	95	57	73	92
Small-group clear cutting:				
Spruce	55	35	38	61
Fir	96	57	58	80
Total	98	69	74	90
Single-tree selection:				
Spruce	64	37	48	69
Fir	64	37	41	77
Total	93	57	76	89

the strip clear-cutting plot. Logging reduced milacre stocking by only 29, 36, and 38 percent on the three plots, however. More fir than spruce was destroyed.

Establishment of new reproduction after logging followed different patterns on the three plots. Only 1,014 new seedlings per acre were established on the strip clear-cutting plots in the first 5 years after logging. In the next 10 years, however, more than seven times that many new seedlings came in. In the first 5 years, 2,111 new seedlings were established on the small-patch clear-cutting plot and only slightly more got started in the following 10 years. Reproduction was heaviest in the first 5 years on the plot cut by single-tree selection (2,264 new seedlings), but it was lightest during the following 10 years (1,670 new seedlings).

After 15 years both total reproduction and numbers of spruce were most abundant on the plot clear cut in strips, and were least on the plot cut selectively.

More spruces than firs came in after cutting by all three methods. This was true for both the 5-year and the 15-year periods after cutting.

Both total stocking and stocking with spruce alone differed little between plots 15 years after cutting (table F-2). Stocking was good (89 to 92 percent of milacres) regardless of cutting method. From 61 to 69 percent of all milacres were stocked with spruce. That is sufficient stocking to provide an excellent representation of spruce in the overstory of the next stand.

Seed spotting holds little promise for reproducing beetle-killed spruce stands

Quantity and distribution of precipitation have been key factors in success of spring seed spotting with lodgepole pine seed in beetle-killed spruce stands on the White River Plateau, Colorado. In the wet summer of 1957, germination was good. In the dry summers of 1958 and 1959, spring-sown seed did not germinate until late August; consequently, the seedlings were unable to harden before winter. Of 2,766 pine seedlings that emerged in 1958, half died before winter and the remainder died by spring. In 1959, germination was still in progress when heavy snows fell on September 14.

After 3 years, only 3 to 13 percent of the seedlings that emerged in 200 seed spots in 1957 were still living. However, 44.5 percent of shaded and sawdust-mulched seed spots were still stocked (table F-3). Spruce seedings have been uniform failures.

Seedling taproot growth appears to be influenced by average air temperature

The weekly growth of taproots of ponderosa pine seedlings that germinated at different times during the summer decelerated at the same time and almost to the same degree during the fall regardless of germination date, seedling size, or depth at which the roots were growing in the soil. Weekly growth correlated closely with the average weekly air temperature (fig. F-1). Whether air temperature has a

Table F-3.--Summary of total living lodgepole pine seedlings and number of stocked seed spots after three growing seasons

Treatment	Survival		Stocked seed spots	
	Number	Percent	Number	Percent
Shade-mulch	189	13.4	89	44.5
Shade	139	10.8	59	29.5
Mulch	120	8.9	55	27.5
None	33	2.7	22	11.0
Total	481	9.1	225	28.1

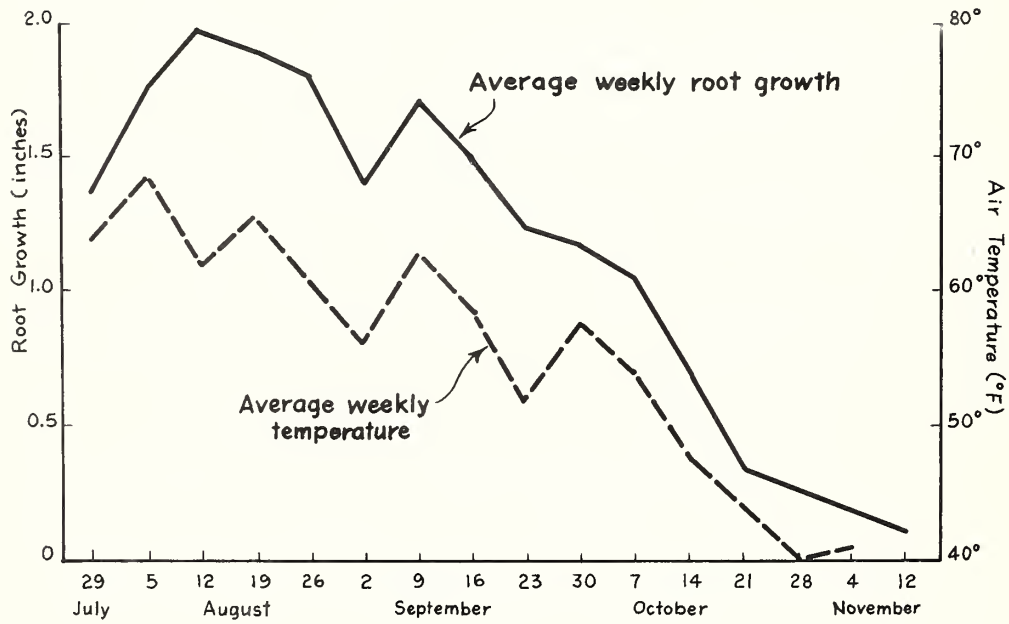


Figure F-1.--Average weekly root growth and average weekly air temperature from July to November. Correlation coefficient is 0.94.

controlling influence on taproot growth, or is simply correlated with another factor such as length of day that has a controlling influence, will be investigated.

Early germination important for survival of ponderosa pine seedlings

In Arizona, seedlings of ponderosa pine that start early in the year survive best. Seedlings that germinated over a 6-week period during the summer of 1957 were grown in glass-faced boxes until late fall. Root penetration, number of lateral roots, and seedling dry weight in November were related to the

time of germination. The early germinating seedlings were larger in all respects. Significant differences in size were found between seedlings germinating as little as a week apart.

Seedlings were also grown on scalped plots from seed that germinated between July 8 and September 9. Although severe frost heaving killed 56 percent of the seedlings overwinter, survival by the following May was directly related to time of germination the preceding summer (fig. F-2). Seedlings that started in July survived much better than seedlings that started in August. Germination as late as August is common in Arizona.

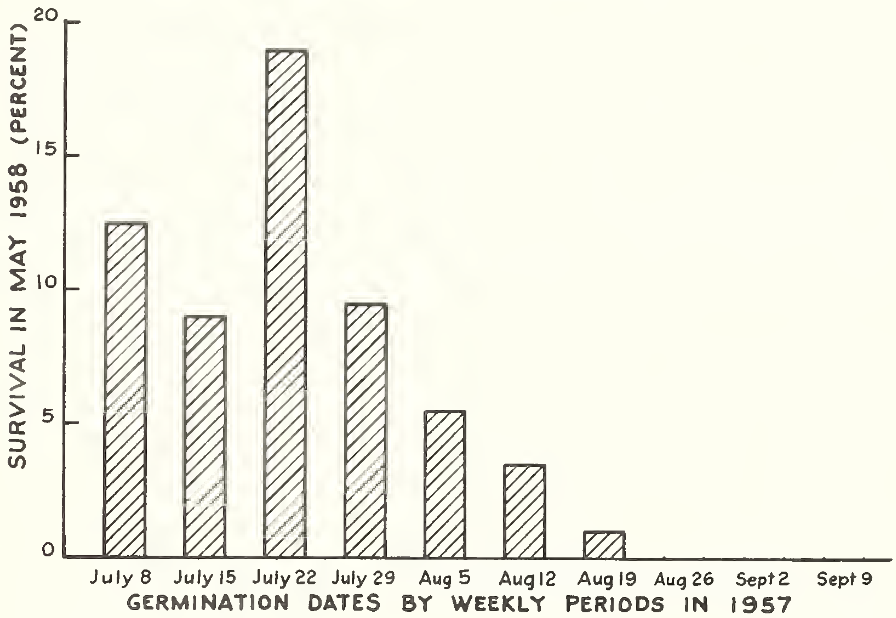


Figure F-2.--Percent survival in May 1958 of seedlings that germinated on different dates during the summer of 1957.

Cubic-foot volume tables for southwestern ponderosa pine published

Station Paper 50 presents cubic foot volume table for immature and mature southwestern ponderosa pine. Separate tables show volumes to a 4-inch top d.i.b. for total heights, and heights to 4-inch and 8-inch d.i.b.'s. Other tables give volumes to an 8-inch top d.i.b. for total heights and heights to an 8-inch d.i.b.

Readily measured factors predict future diameters and volumes of immature ponderosa pine in Black Hills

Future average diameter, basal area, and volume of immature stands of Black Hills ponderosa pine can be estimated from present measurements. Only

an inventory of the present stand and a measurement of site index are required. Hypothetical values may also be used to compare potential yields under alternative methods of treatment.

To estimate future average stand diameter:

$$Y_{10} = 1.575 + 1.131X_1 - 0.011X_1^2 - 0.966 \log X_2 + 0.016X_3$$

$$Y_{20} = 2.431 + 1.268X_1 - 0.021X_1^2 - 1.540 \log X_2 + 0.028X_3$$

where:

Y = average stand d.b.h. in 10 or 20 years

X_1 = present average stand d.b.h.

X_2 = basal area per acre

X_3 = site index

To estimate future basal area:

$$Y_{10} = 26.51 + 0.811X_1 + 0.477X_2 - \frac{4709.256}{X_3}$$

$$Y_{20} = 132.14 + 0.786X_1 + 0.715X_2 - \frac{6971.516}{X_3} - 48.592 \log X_4$$

where:

Y = basal area per acre in 10 or 20 years

X_1 = present basal area per acre

X_2 = site index

X_3 = number of trees per acre

X_4 = age

To estimate future total cubic foot volume:

$$\log Y_{10} = 1.444 + 0.136 (\log X_1)^2 + 0.374 \log X_2 - \frac{19.456}{X_3} - 0.001X_4$$

$$\log Y_{20} = 1.515 + 0.083 (\log X_1)^2 + 0.640 \log X_2 - \frac{14.212}{X_3}$$

where:

Y = future cubic feet per acre

X_1 = present cubic feet per acre

X_2 = site index

X_3 = number of trees per acre

X_4 = basal area per acre

Future merchantable cubic foot and cordwood volumes in trees 6.0 inches d.b.h. and larger can be computed from future total cubic foot volume. Total volume can be converted to merchantable volume by multiplying total volume by the ratio appropriate for average d.b.h. of the stand. Merchantable volume can then be changed to cords by using a conversion factor.

The results are applicable to even-aged stands within the measured ranges of the variables used in the equations. Estimates should be restricted to stands 1.9 to 10.8 inches d.b.h. with 200 to 5,575 trees per acre. Site indexes measured ranged from 37 to 73 feet at a base age of 100 years.

Site index as established for ponderosa pine growing in Nebraska windbreaks

Height-over-age curves for ponderosa pine in Nebraska windbreaks will rate site index at a base age of 15 years within ± 1 foot at 14 years from planting date to ± 3 feet at 22 years (95 percent confidence level). Errors are too great to predict site index from trees established less than 8 years (fig. F-3).

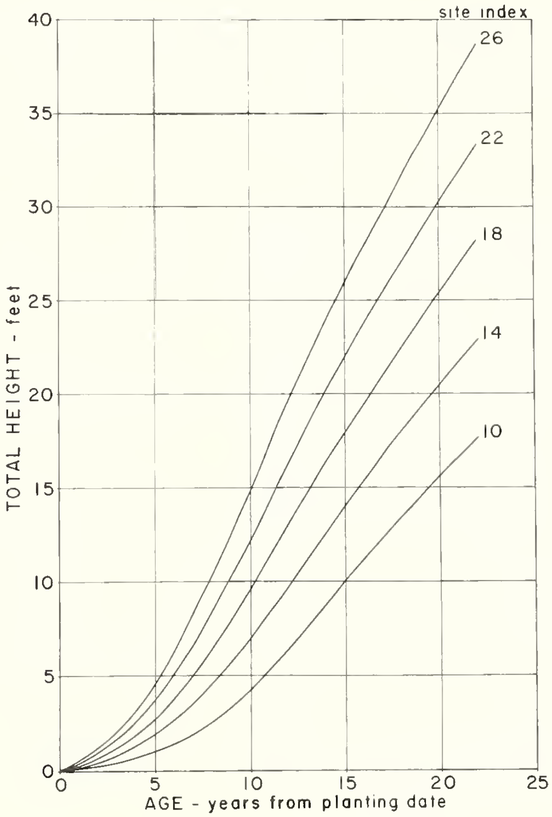


Figure F-3. --Site indexes at age 15 for ponderosa pine planted in Nebraska windbreaks.

The site-index curves were based on a total of 150 ponderosa pines measured at 22 different locations in 20- to 25-year-old windbreaks in Nebraska. They are known to apply only in Nebraska.

Site index promises to be useful for classifying ponderosa pine sites in soil-tree growth investigations and for identifying factors that cause atypical height growth.

Repellents reduce browsing of ponderosa pine by mule deer

Treatment of badly browsed small ponderosa pines in Arizona with 10 percent TMTD (active ingredient tetramethylthiuramdisulfide) and ZAC (active ingredient zinc dimethyl dithio carbamate cyclohexylamine complex) reduced browsing by mule deer. The two repellents were equally effective.

ZAC was applied to 500 twigs and TMTD to 465 twigs on May 29, 1958, and 500 untreated twigs were tagged to serve as controls. Browsing was checked each week through the 1958 and 1959 growing season.

Browsing was done only during the period of shoot elongation, which was from May 29 to August 1 in both years. In the first year, 56 percent of untreated twigs were browsed; whereas only 9 and 8 percent of twigs treated with ZAC and TMTD, respectively, were browsed (fig. F-5). The effect of the repellents did not carry over to the second growing season.

Figure F-4.--Badly browsed tree treated with 10 percent ZAC when 3.4 feet tall. It grew 14.5 inches in the year when treated.

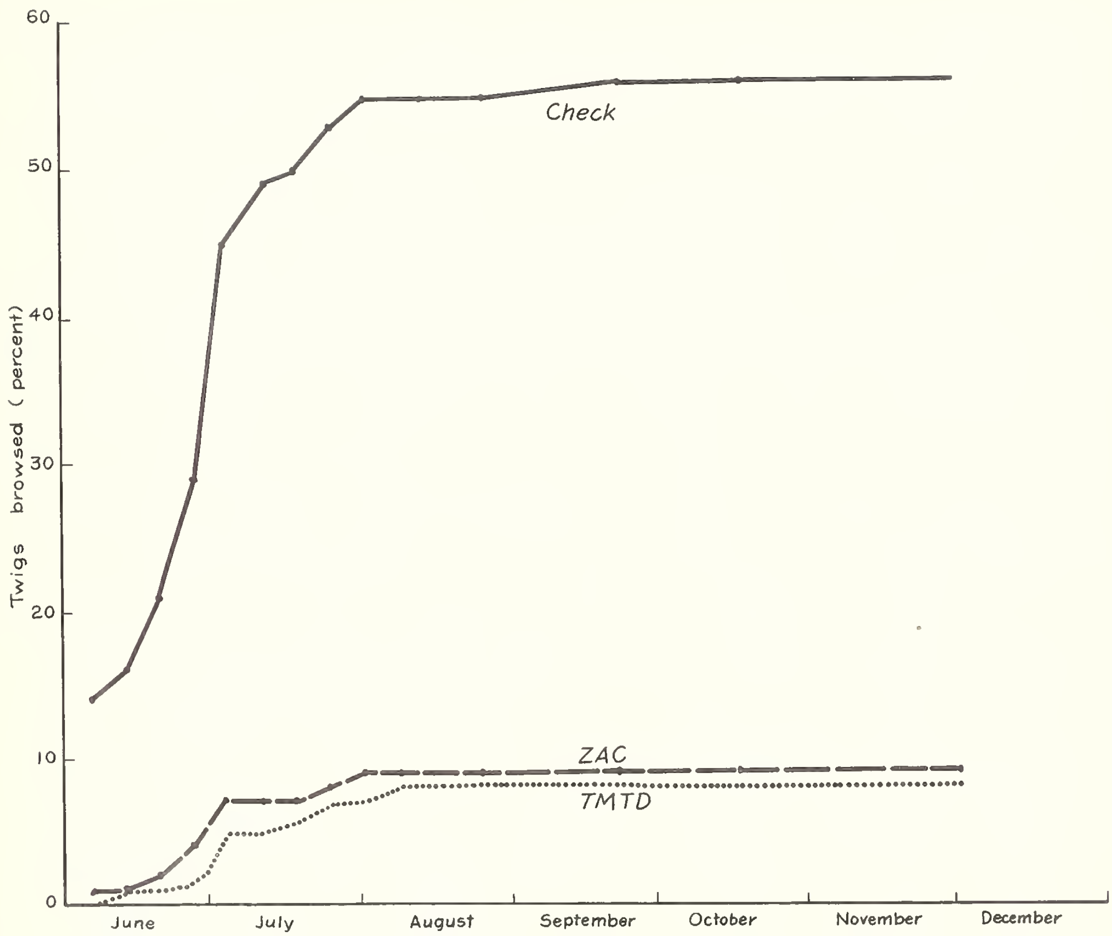


Figure F-5. --Cumulative percentage of twigs browsed by dates, 1958.

Dwarfmistletoe reduced in an Arizona ponderosa pine stand through silvicultural measures

Three cutting treatments were applied in a virgin ponderosa pine stand on the Fort Valley Experimental Forest from 1951 to 1954. Each treatment was applied to three 25-acre plots. Light to heavy infections of dwarfmistletoe in trees of all age classes were well distributed throughout the stand. Two of the cutting treatments were designed specifically to control dwarfmistletoe. The third was the light improvement-selection cutting that is used widely in the Southwest. The treatments and their objectives were as follows:

1. Limited control--to reduce infections to a level unimportant to the growth and production of timber, using funds and measures then available to the national forests.

2. Unlimited control--to eradicate dwarfmistletoe in the shortest possible time irrespective of costs or influence on the stand.

3. Light improvement-selection placed first emphasis on removing trees that are likely to die before the next cut, second emphasis on removing trees that are a disease hazard or otherwise undesirable in the stand, and third emphasis on removals to improve spacing.

The first harvest cut removed 77 percent of the merchantable volume under limited control, 73 percent under unlimited control, and 35 percent under improvement-selection. Infected merchantable volume was reduced from 44 to 10 percent under limited control, from 50 to 6 percent under unlimited control (obscure infections were missed in some trees) and from 40 to 36 percent under current marking practices. Subsequent pulpwood cutting and stand improvement reduced the infected volume to 8 percent (limited control), 1 percent (unlimited control), and no change (improvement-selection) (fig. F-6).

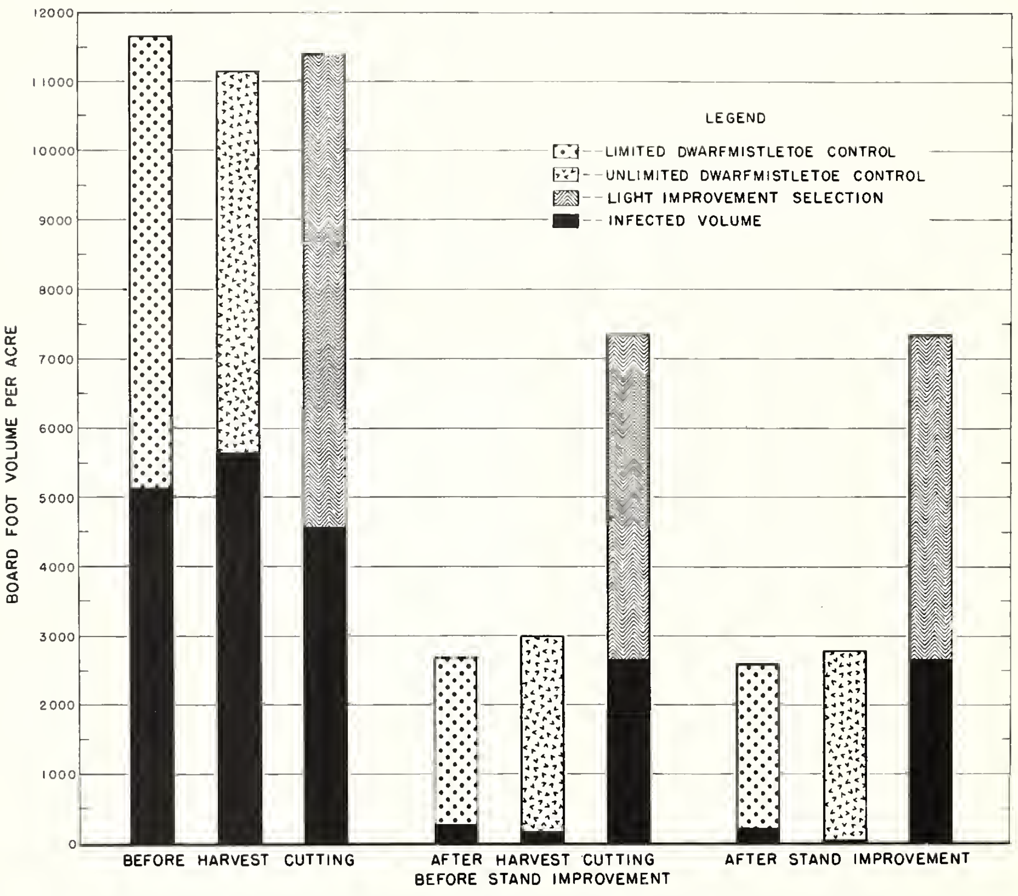


Figure F-6. --Effect of three different harvest-cutting and stand-improvement practices on total volumes of ponderosa pine sawtimber and volumes infected with dwarfmistletoe.

The first harvest cut, logging damage, and stand improvement reduced the total number of stems 1 foot tall and larger from about 590 to 290 (limited control), 520 to 295 (unlimited control), and 500 to 445 (improvement-selection). The proportions of the total remaining stand infected after stand improvement were 20 percent, 3 percent, and 29 percent, respectively, for the three treatments (fig. F-7).

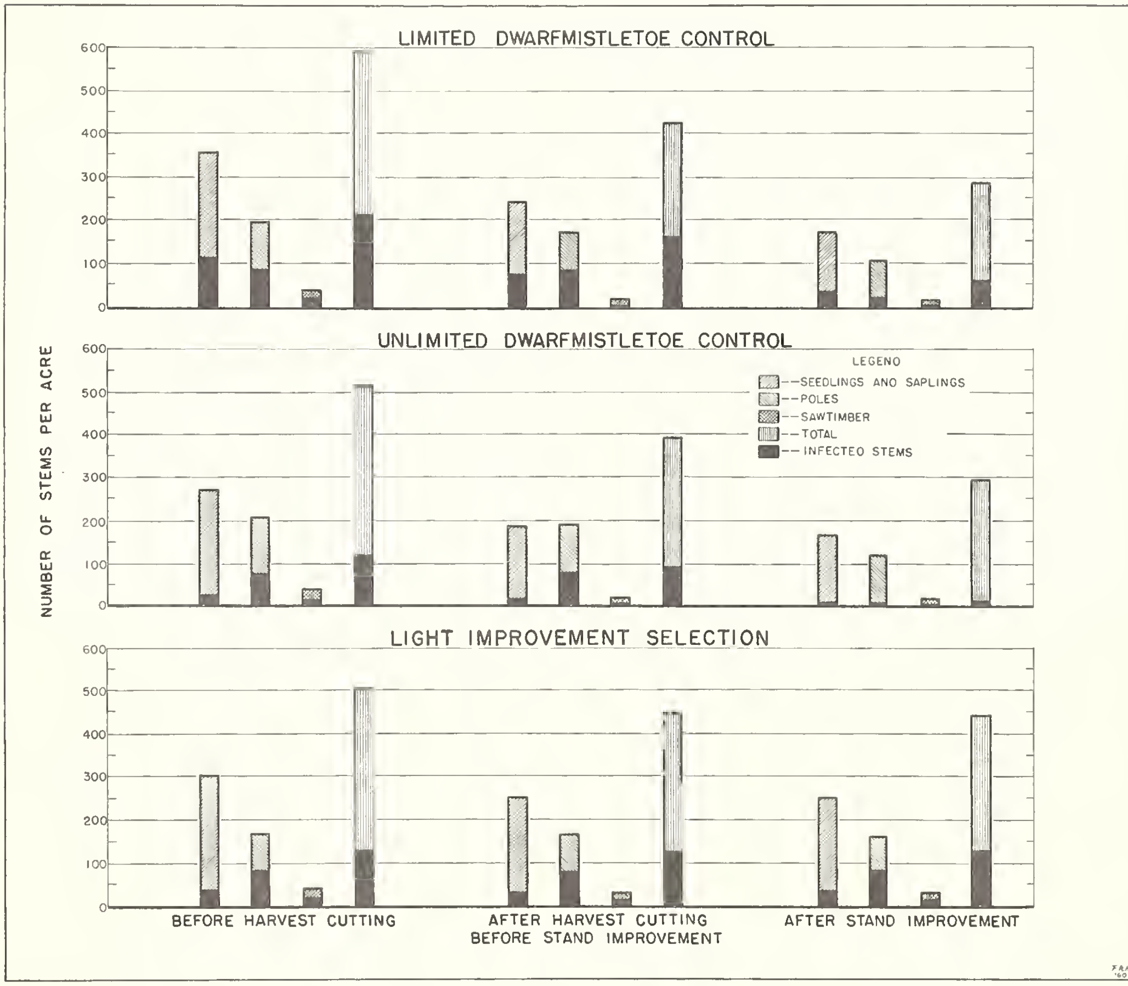


Figure F-7. --Effect of three different harvest-cutting and stand-improvement practices on total numbers of trees of different size classes, and numbers infected with dwarfmistletoe.

Total stocking, according to a point sampling system adapted to many-aged stands, was reduced to 56 percent (limited control), 53 percent (unlimited control), and 80 percent (improvement-selection). Only 4 and 3 percent of the remaining stocking on limited and unlimited control areas, respectively, were infected with dwarfmistletoe; whereas 40 percent (one-half of remainder of the stocking) on the improvement-selection area was infected (fig. F-8).

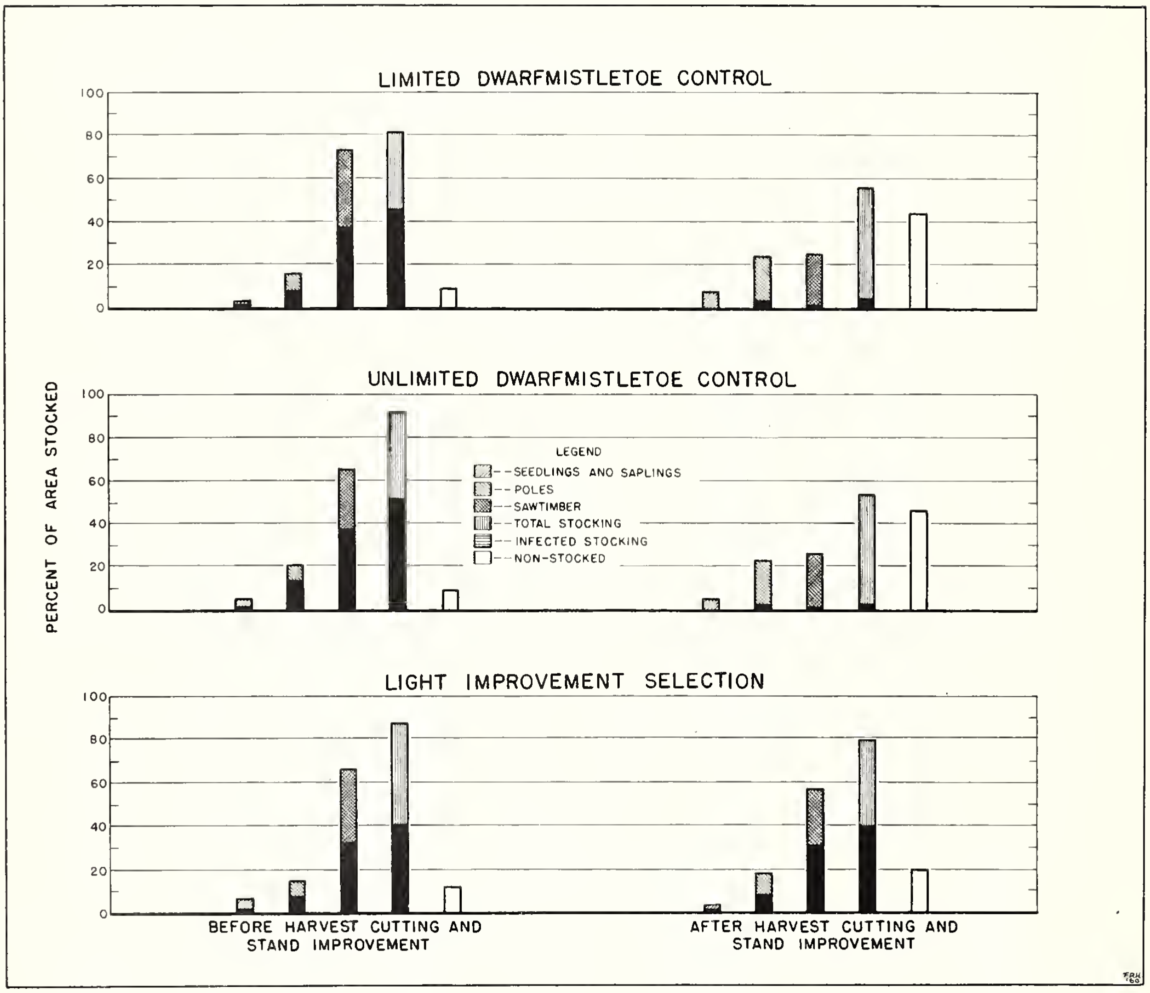


Figure F-8. --Effect of three different harvest-cutting and stand-improvement practices on total stocking and stocking infected with dwarfmistletoe.

Any selection system of cutting that is designed to invigorate remaining trees tends also to increase vigor and spread of dwarfmistletoe. If dwarfmistletoe is to be controlled, cuttings designed specifically for the purpose will have to be applied. It may be necessary to nearly clear cut the usually small, heavily infected parts of stands (fig. F-9).

Results show that dwarfmistletoe was reduced greatly by single applications of two levels of silvicultural treatments designed for that purpose. Followup treatments will be necessary to attain near-eradication. Second cuts on all plots are being made and the studies will be continued.

Figure F-9. --Unlimited control virtually clear cut a sapling and pole stand that was within seeding range of the two badly infected overstory trees, labeled A and B.

Young pinyon pine
and juniper trees
grow slowly

Young pinyon pines and one-seeded junipers in Arizona have increased in height at an average rate of only about one-half foot per 10 years (figs. F-10 and F-11) for the past 20 years. The crowns of these young trees invading grasslands are approximately as wide as the trees are tall.

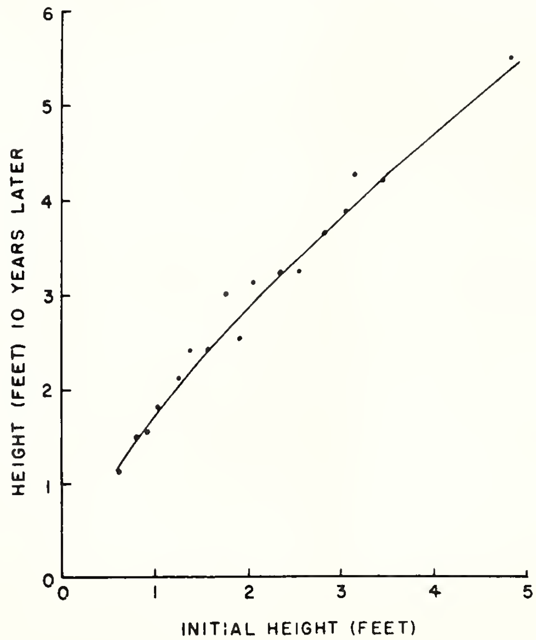


Figure F-10. --
Height growth of
pinyon trees in
10 years.

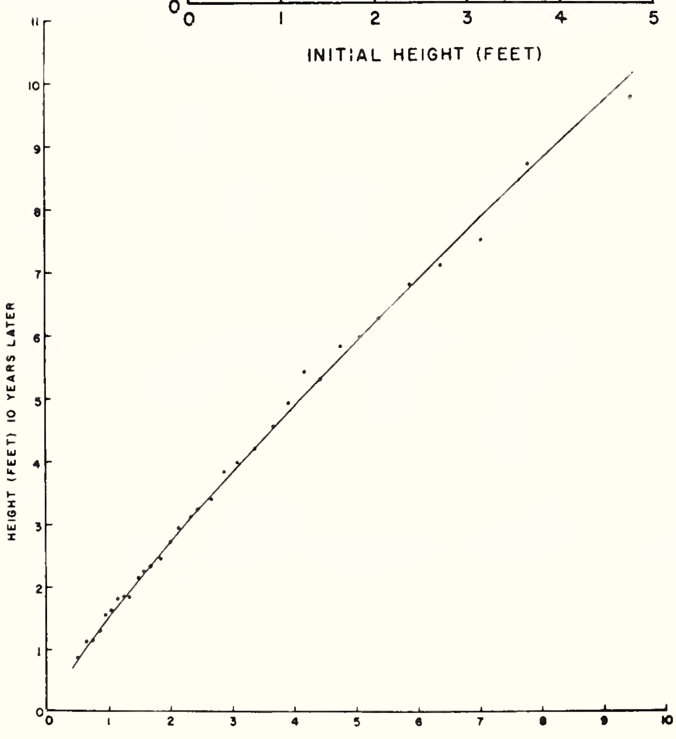


Figure F-11. --
Height growth of
one-seeded junipers
in 10 years.

Some effects of intentional burning on subsequent forest fire control load

Lightning-fire occurrence and area burned has been compared on ponderosa pine forests that had been control burned and not burned on the Fort Apache Indian Reservation in Arizona. Records covered 8 years for 65,000 acres burned in 1950, and 5 years for 42,500 acres burned in 1954. Records for 35,200 unburned acres provide the comparison.

Both fire occurrence and area burned were slightly less on the burned areas than on the unburned (tables F-4 and F-5). The differences were too small, however, to be significant statistically.

Table F-4. --Number of fires per 100,000 acres per year, Fort Apache Indian Reservation, Arizona

Year	Control burned			Not burned
	1950	1954	Average	
	------ Number ------			
1952	13.8	--	13.8	19.9
1953	26.2	--	26.2	25.6
1954	10.7	--	10.7	22.6
1955	33.9	21.2	27.6	28.4
1956	53.8	94.1	74.0	71.1
1957	20.0	9.4	14.7	34.0
1958	33.9	49.4	41.6	45.5
1959	61.5	68.3	64.9	42.7
Means[1]	31.7	48.5	34.2	36.2

[1] Not significantly different at the 5 percent level.

Table F-5. --Percentage of protected area burned each year during 1955-59 in the units burned in 1950 and 1954 and in the unburned unit, Fort Apache Indian Reservation, Arizona

Year	Unit burned in 1950	Unit burned in 1954	Unit unburned
	---- Percent ----		
1955	0.03	0.002	0.02
1956	.05	.09	.22
1957	.01	.002	.72
1958	.03	.34	.01
1959	.03	.05	.24
Means[1]	.03	.10	.24

[1] Not significantly different at the 5-percent level.

On close examination, fire occurrence appears to be approximately random among the burned and unburned areas.. In 3 years out of 8 the fire occurrence rate was higher for the combined burned areas than for the unburned, and for 5 years out of 8 the occurrence rate on one or other of the two burned areas was higher than on the unburned (table F-4).

The percentage of area burned annually was more consistently greater on the burned areas. In 4 years out of 5 the proportion of area burned was less on the burned areas than on the unburned during the 5 years for which data were available for all areas (table F-5).

Moisture in leaves and twigs of chaparral differs

The moisture in leaves of turbinella oak differs sufficiently from the moisture in twigs that the two should be sampled separately to assess the flammability of oak chaparral. The yearlong average moisture in leaves was about 25 percent higher than in twigs, as shown below:

Time of sampling	Leaves	Twigs
	(Percent)	
September 2, 1959 (22 samples)	109.4	77.9
September 18, 1959 (22 samples)	97.0	67.3
Yearlong (65 samples)	96.2	71.5

The difference is greater during wet periods and less during dry.

New foliage contains much more moisture than old leaves on the same plants. The differences disappear quickly, however, as the new leaves mature.

The moisture content of leaves and twigs is not correlated over short periods of time. On 2 days when moisture was determined periodically throughout the daylight hours, moisture changes in leaves and twigs differed so greatly that the two were not significantly correlated.

Forest Biology

(In cooperation with U. S. Fish and Wildlife Service)

Pocket gophers feed on rabbitbrush

Rabbitbrush (*Chrysothamnus parryi*) was frequently the focal point of pocket gopher activity on Thurber fescue (*Festuca thurberi*) range, Black Mesa experimental area, western Colorado. Mounding around the base of these plants was found to raise such areas above the surrounding ground level. The dirt cores (casts) deposited in the snow during winter also were commonly found close to and through rabbitbrush plants (fig. B-1).

Figure B-1.--Rabbitbrush was frequently the center of pocket gopher activity in gopher-infested areas, as shown by old mound and the winter cast at base of this plant. Defoliated, debarked, and clipped stems show evidence of winter-feeding activity.

Rabbitbrush was frequently defoliated, debarked, and clipped back almost to ground level by pocket gophers in the fall and winter, and clipped plants had to begin new stem growth each summer (fig. B-1). In gopher-free exclosures, however, these plants were able to begin growth from established stems and leaves (fig. B-2). Continued heavy feeding by pocket gophers may result in mortality of rabbitbrush and limit its abundance (fig. B-3).

Figure B-2. --Rabbitbrush stems were not defoliated, debarked, or closely clipped in pocket gopher-free area. This plant did not have to begin new growth from heavily clipped stems or the root crowns.

Figure B-3. --Dead stubs of rabbitbrush (immediately in front of ruler) were present on Black Mesa range. Mortality can result from repeated stem clipping by pocket gophers.

Pocket gopher population on Black Mesa remains low

Counts of pocket gopher cast in the spring of 1960 on the Thurber fescue rangelands, Black Mesa experimental area, in western Colorado, disclosed a low 1959-60 pocket gopher population. The percentage of ground covered by winter pocket gopher casts on permanent transects was only 0.7 in the spring of 1960 compared with 2.6 in 1959 and 2.9 in 1958.

As indicated by mound counts in the fall of 1959, the pocket gopher population was low at the beginning of the winter season. Only 48 new mounds were thrown up in a 48-hour period on a series of permanent plots. Similar counts made in the fall of 1960 did not show any marked recovery from the 1959 low. Only 53 fresh mounds were found. In 1958 and 1957, years of higher populations, 295 and 194 mounds, respectively, appeared on the plots. The number of young produced in the single breeding season following the low year was not sufficient to bring the population back to its former level.

Deer mouse common on western Colorado rangelands

Next to pocket gophers, deer mice were the most common small mammal on the Black Mesa experimental area. The population reached a high in 1956, followed by a low in 1957. The high of 1956 has not been repeated in 4 years' time. The deer mouse catch per 100 trap nights on the Black Mesa experimental area was as follows:

Year	Grazing treatment: Light use (No.)	Moderate use (No.)	Heavy use (No.)	Average (No.)
1954	11.4	10.8	19.4	13.9
1955	--	--	--	--
1956	15.0	19.1	28.3	20.8
1957	1.7	.3	.5	1.0
1958	3.3	3.0	2.2	2.8
1959	5.8	5.5	3.6	5.0
1960	6.4	6.7	9.7	7.6

There was less than one deer mouse per acre under all grazing treatments in the low year of 1957; this increased to two mice per acre under light and moderate grazing, and three per acre under heavy grazing, in 1960.

The meadow vole, redbacked vole, western jumping mouse, and Colorado chipmunk were also found on the Black Mesa study areas, but these animals did not approach the population levels of the deer mouse.

Small mammals on grazed and ungrazed winter range studied

Deer, pinyon, and harvest mice, Ord's kangaroo rats, antelope ground squirrels, desert cottontails, and black tailed jackrabbits were found on the Badger Wash experimental area in western Colorado (fig. B-4). Deer mice were the most abundant small mammal onthe experimental watersheds. However, their numbers fluctuated from year to year; a population low occurred in 1959, a high in 1960. The deer mouse catch per 100 trap nights on the Badger Wash experimental area is shown below. The ungrazed area has been protected since 1953.

Year	Grazed area (No.)	Ungrazed area (No.)	Average (No.)
1957	9.7	10.9	10.3
1958	13.3	9.4	11.4
1959	2.8	2.5	2.6
1960	9.8	14.2	12.0

The small mammal inventory work was done on eight experimental watersheds in the salt-desert shrub type. Four of the watersheds were fenced in 1953 to exclude grazing. The other four were grazed by both sheep and cattle in winter. There were about four deer mice per acre on the ungrazed watersheds in 1960, the high year in the inventory, and fewer in the grazed watersheds. However, no consistent trend toward a buildup in population of these animals was apparent on the protected or ungrazed watersheds in the 4 years of observation. Other small mammals, cottontail rabbits, and jackrabbits were not abundant.

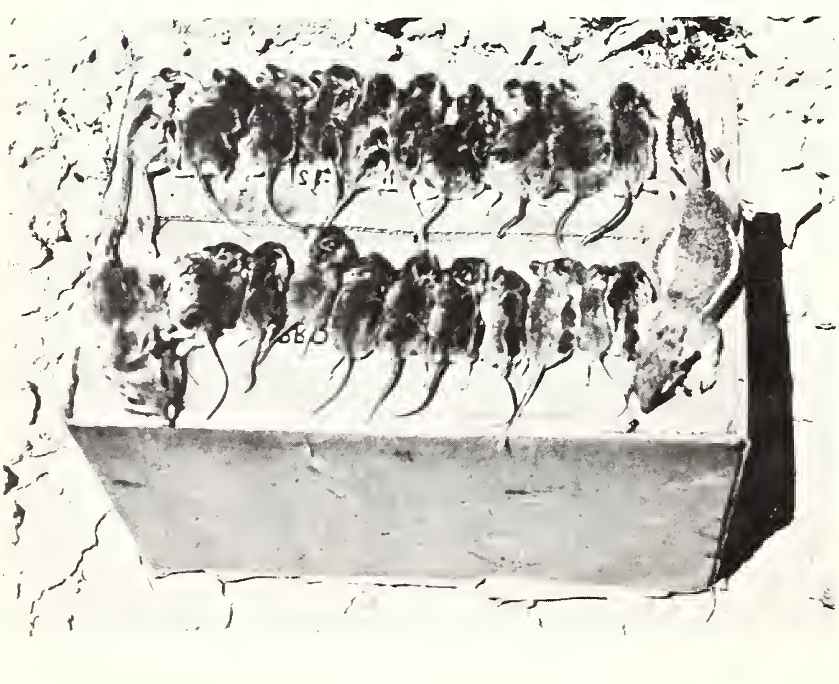


Figure B-4.--Deer mice (center) were the most common small mammal on the eight Badger Wash experimental watersheds as shown by one night's catch. Other animals such as antelope ground squirrels (right) and kangaroo rats (left) were less abundant.

Forest Utilization Research

Residues resulting from logging and milling industry determined for Black Hills area

In response to increased interest in the various forms of residue for pulpwood, a study to measure this resource was undertaken in the Black Hills. Measurement by weight was used to facilitate conversion to pulp and paper products. The measurements were also converted to units per M b.m. rough lumber for survey purposes. Figure U-1 illustrates the lumber and chippable residues accruing from a ponderosa pine log. A total of 5,662 pounds of moisture-free residue results from the production of one M b.m. rough lumber. This corresponds to approximately three rough cords of ponderosa pine pulpwood, dry basis, and emphasizes the impact that the recovery of this material could have on the overall timber resource in the event of the establishment of full-scale pulpwood market.

Mill residue constitutes the major volume that can be recovered more readily than residue resulting from logging. Total mill residue was found to make up about 80 percent of the total volume of residue resulting from the logging operation. Bark, and in most cases sawdust, are not acceptable for pulping, thus the net amount of moisture-free mill residue was found to be 1,554 pounds per 1,000 board feet of lumber produced.

The logging phase of the study was based on six operations; whereas, the sawmill residues were measured at two circular sawmills and two sawmills equipped with resaws.

Figure U-1.--Chippable residues and lumber from a Black Hills ponderosa pine log.

Kinds and amount of residues (moisture-free weight) produced from Black Hills ponderosa pine were:

	Pounds per M b.m. rough lumber tally
From logging:	
Tops, 8 inches d.i.b. to 4 inches d.i.b.	[1] 610
Cull logs and unmerchantable pieces of logs	[1] 660
Total	[1] 1,270
From circular head saw:	
Bark	568
Sawdust	1,505
Slabs	934
Edgings	316
Trim	208
Cull lumber	96
Total	3,627
From planing:	
Shavings	681
Trim	84
Total	765

[1] Pounds per 1,000 board feet net Scribner log scale. When based on rough lumber tally from circular mills the weights of tops and cull logs are 504 and 545 pounds per M b.m., respectively.

Pulp chip production underway in the Black Hills

The first significant utilization of sawmilling residue in the central Rocky Mountain area became a reality with the establishment of a pulp chip plant near Custer, South Dakota (fig. U-2). The new plant, which was established by the M & G Paper Company of Green Bay, Wisconsin, is equipped with a 50-inch, 16-knife Norman chipper, along with the necessary screening and conveying equipment to produce 10 boxcars of pulp chips a week. A boxcar holds approximately 20 units, or 240,000 pounds of chips (dry basis). The loaded cars are shipped to Wisconsin.

Figure U-2.--Central pulp chipping plant near Custer, South Dakota. Here bark-free slabs, edgings, and cull lumber from five sawmills are chipped for shipment by railroad boxcars to Wisconsin pulp and paper mills.

Figure U-3.--Debarked slabs delivered to the chipping plant at Custer, South Dakota.

Specific gravity determined for Arizona ponderosa pine pulpwood

Interest in ponderosa pine pulpwood in northern Arizona has increased the need for information on wood density and specific gravity. Accordingly, an exploratory study was undertaken in cooperation with the Division of Forestry, Arizona State College.

Full-length increment cores were taken at breast height from 109 pulpwood-sized trees within a 30-mile radius of Flagstaff, Arizona. Specific gravity (green-volume, ovendry-weight basis) and wood density (pounds per cubic foot) were computed for each tree. Mean specific gravity was 0.404 and mean density was 25.2 (table U-1).

Table U-1.--Specific gravity and density at breast height of ponderosa pine by the increment-core method

Location	Trees	Diameter range (d.b.h.)	Specific gravity		Density	
			Mean	95-percent confidence interval	Mean	95-percent confidence interval
	Number	Inches			Lbs. per cu. ft.	
Cinder Hills	10	6.9-20.4	0.40500	±0.03854	25.283	±2.406
Rogers Lake	20	6.1-18.6	.40194	± .01750	25.092	±1.092
Highway 89A	40	5.6-15.7	.41278	± .01217	25.769	± .760
Fort Valley	19	6.0-18.5	.38253	± .01006	23.881	± .628
Lake Mary	20	5.9-14.1	.41047	± .01900	25.625	±1.186
All	109	5.6-20.4	.40438	± .00717	25.245	± .448

Colorado aspen equivalent to that grown in Lake States for pulp and paper manufacture

Pulping tests conducted by the Forest Products Laboratory revealed that Colorado aspen was a satisfactory pulpwood species and comparable to Lake States aspen. The test sample was taken from a stand near Kremmling, Colorado. The test material averaged 6.8 inches in diameter and 46 years in age. The average density, (moisture-free weight and green volume) was 20.8 pounds per cubic foot. The wood was subjected to groundwood, sulfite, semichemical, and sulfate pulping and papermaking tests. The sulfite pulp proved somewhat stronger than a comparable pulp made from Lake States aspen. Pulp made by the other processes revealed that the properties of the two sources were practically identical.

Log diameter major factor in ponderosa pine sawing time study

The headsaw time required to saw ponderosa pine logs may depend on several factors. In this study, log diameter, log grade based on Pacific Northwest ponderosa pine log grades, and log defect were tested to determine the influence of each of these variables on sawing time.

Of the factors analyzed, only log diameter was significantly related to sawing time (fig. U-4). From this, it is possible to determine the time required to saw ponderosa pine logs of various scaling diameters. The standard error of the estimate is 9.7 seconds. In the relationship of sawing time per 1,000 board feet (Scribner Decimal C log rule) to log diameter, which is also shown, the standard error of the estimate is 29.3 seconds.

The relation of sawing time to log diameter can be expressed by the equation:

$$Y = 25.56 + 0.23X^2$$

where

Y = sawing time in seconds

X = (diameter of log in inches)^2

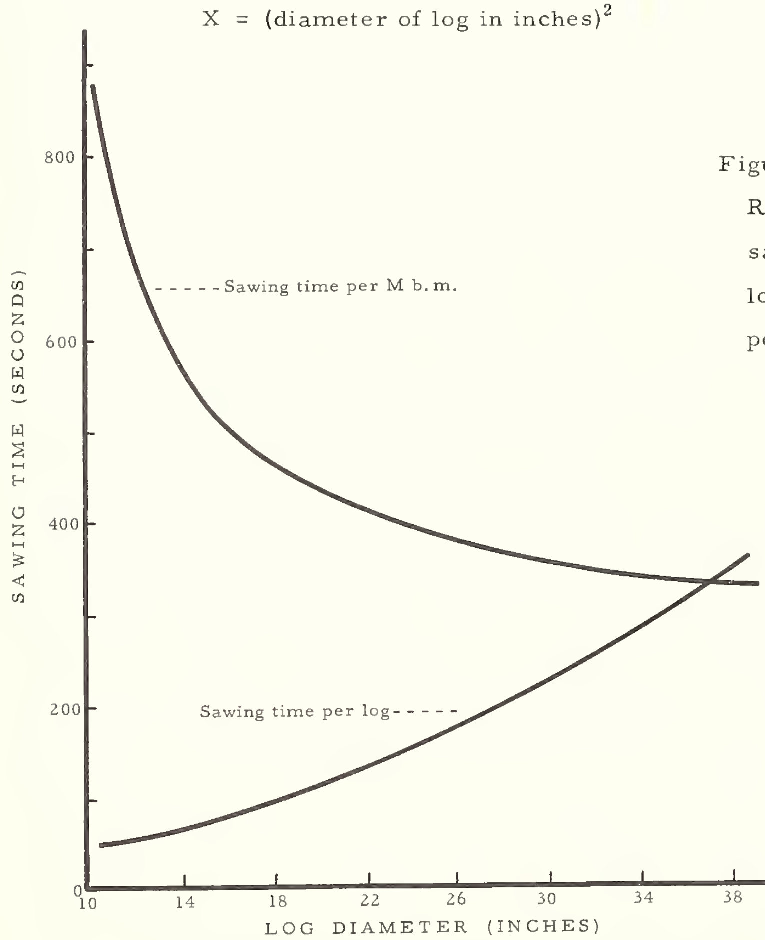


Figure U-4.--Relationship of sawing time to log diameter in ponderosa pine.

Possible effect of log grade and log defect on sawing time was tested by covariance analysis. Relations tested were: effect of log grade, effect of defect (all grades), effect of log grade by sound and defective logs, and effect of defect by each log grade. No significant differences in sawing time were found for any of these comparisons.

Trial log-grading system shows promise in grading Colorado lodgepole pine

Application of a trial log-grading system to lodgepole pine logs in a lumber-grade recovery study in northern Colorado resulted in promising quality differentiation. The system tested is patterned after the trial set of grades developed for associated species in the Pacific Northwest region. The diameter range was modified to fit lodgepole pine. Quality separation obtained through grading appears substantially improved over that obtained through diameter classification alone.

The presence of numerous small knots, a characteristic of lodgepole pine, makes grading difficult and time consuming, and points up the need of perhaps developing other grading criteria.

Relatively high yields of up to 80 percent in No. 3 common and better lumber grades can be expected from lodgepole pine sawtimber stands (fig. U-5). Also apparent is the proportionately greater yield of low-grade lumber from the defective logs in all log grades.

Hidden defect reduces overrun in older lodgepole pine

Lumber yields in mature lodgepole pine stands in northern Colorado are closely associated with the amount and nature of decay present. Appreciable decay in the form of hidden defect may result in overrun values as low as 2.5 percent.

This is brought about by the fact that no scale deduction can be made for hidden defect and the logs are therefore classified as sound. When the defect is visible and a scale deduction is made, increased overrun usually results because some of the volume deducted in the cull allowance is salvaged in the sawing operation (table U-2).

Study logs were representative of old-aged lodgepole pine, some of which was overmature. Considerable hidden defect (heart rot) was observed as the logs were opened. The resulting total overrun of 2.5 percent shows that where this condition does exist, the usually higher overrun that generally results when Scribner Decimal C log scale is applied to small-diameter logs cannot be anticipated.

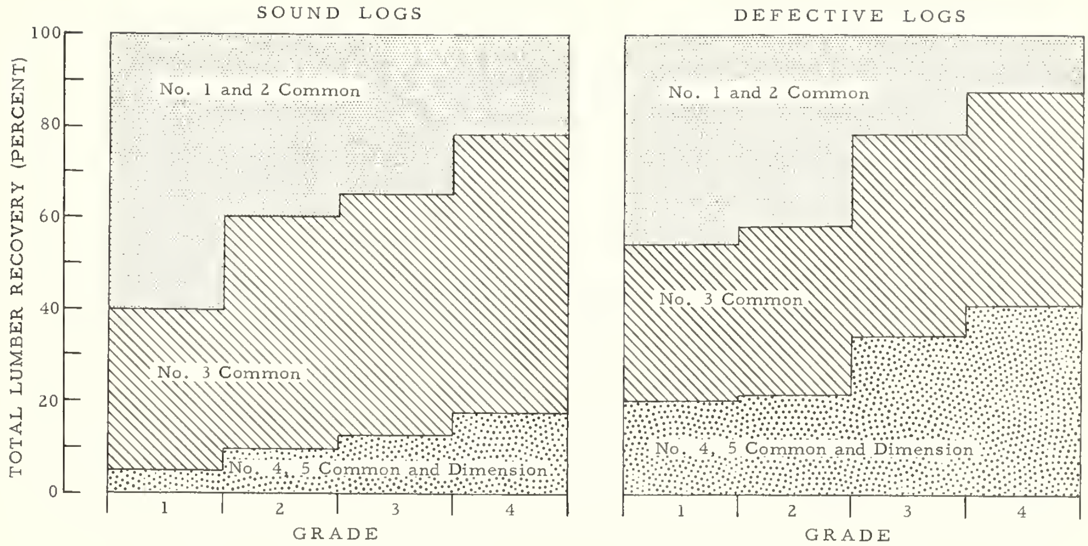


Figure U-5. --Lumber-grade recovery by log grade and log-soundness class, 16-foot logs.

Table U-2.--Percent overrun by log-soundness class (lodgepole pine)

Log soundness class	Logs	Net log scale Scribner Dec. C	Net lumber tally	Overrun
	Number	Bd. ft.	Bd. ft.	Percent
Sound	656	36,050	35,710	-0.94
Defective	169	9,460	10,928	15.52
All	825	45,510	46,638	2.48

Sash-gang saw reduces lumber production time and improves utilization

The sawmill at which the recovery study was conducted was equipped with both circular and sash-gang head saws. In a study of the production performance of the two headrigs, the sash-gang saw excelled in both sawing accuracy and rate of production. Total sash-gang sawing time per M b.m. for the full range of log diameters was only half the time required for the circular saw (fig. U-6).

Comparison of sawing quality was based upon variation between average thickness of boards and saw setting. Average board thicknesses were computed from three measurements taken along one edge, at points 2 feet from each end, and at the midpoint. The superior accuracy of the sash-gang saw

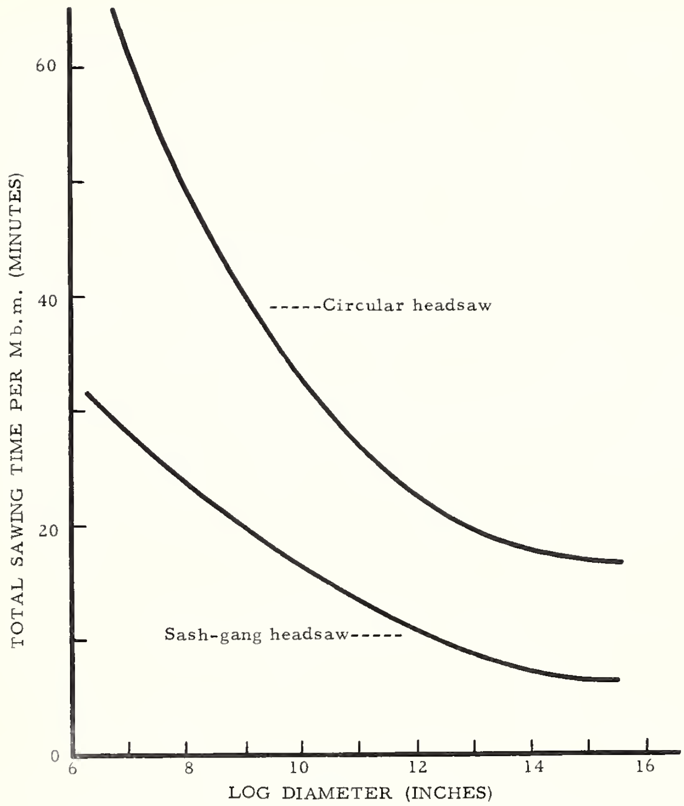


Figure U-6.--
Total sawing time per M b.m. for circular and sash-gang head saws.

is quite evident. It operated successfully at a thickness setting of 31/32 of an inch; whereas, the circular saw required a thickness setting of 35/32 of an inch to avoid cutting undersized boards (fig. U-7).

A further significant result was the lack of any difference in grade recovery between the two headrigs. The defect in lodgepole pine prevented the circular headrig from recovering significantly better grades.

Seasoning and surfacing degrade determined for air-seasoned Engelmann spruce lumber

A lumber degrade study conducted on Engelmann spruce shows that appreciable grade change and volume loss occurs in current air-seasoning and surfacing practices (table U-3). Results based on 30,000 board feet of 4/4 lumber emphasize the importance of proper seasoning and surfacing. The sample was tallied by green grade, then tallied again by shipping grade after surfacing and final trimming. The study lumber contained representative samples of all common grades, and included lumber of all nominal widths, 4-inch through 12-inch.

Degrade information for D and better select lumber was not available at the time the study was conducted, but will be obtained in the near future.

Aggregate volume loss resulting from seasoning and surfacing the degrade study lumber amounted to 8.66 percent of the green-recovery volume.

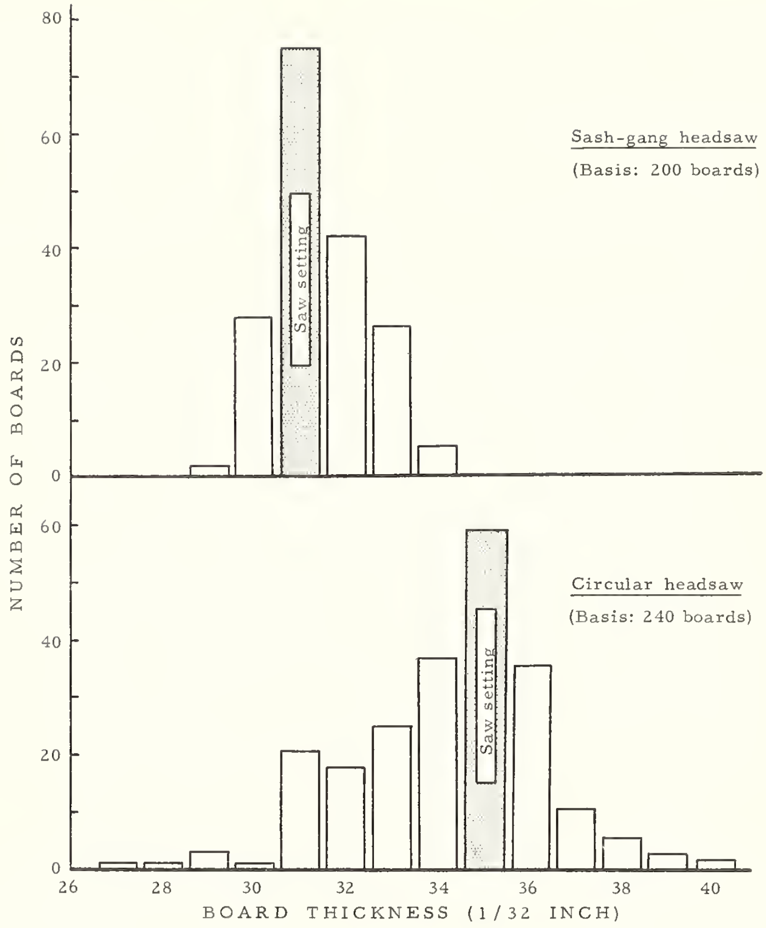


Figure U-7. --Board-thickness variation for circular and sash-gang head saws. The shaded bar shows actual saw setting at which all boards were sawed.

Table U-3. --Change of lumber grade from green grade to shipping tally

Rough green		Dry-surfaced grade distribution					
Grade	Volume	1&2c	3c	4c	5c	Trim & cull loss	Total
	Bd. ft.	- - - - - - - - - - - -	-	Percent	- - - - - - - - - - - - -		
1&2c	13,647	49.94	38.38	6.86	0.19	4.63	100
3c	10,171	7.01	65.87	16.87	.78	9.47	100
4c	5,327	.23	6.86	72.77	5.24	14.90	100
5c	966	--	.32	12.97	64.11	22.60	100

End checks and splits associated with excessive spiral grain accounted for most of the volume loss. With exception of the top courses, losses resulting from cupping and warping were minimized by the generally good piling practices. The lumber had been in the seasoning yard without pile covers for approximately 5 months beginning in June. This is a considerably longer time than is usually required to season spruce and possibly it accounted for some of the losses, particularly in the top courses. The long seasoning period was brought about by the soft market. The average air-seasoning period for 4/4 Engelmann spruce in this general area during the summer is 3 to 4 weeks to reach a moisture content of 19 percent. The moisture content of the study lumber was 12 to 15 percent.

Paper-overlaid lumber performing well at Rapid City, South Dakota

In August 1958, the South Dakota School of Mines and Technology at Rapid City, South Dakota, replaced the wood treads and seats in their stadium (fig. U-8) with penta-pressure-treated 2- x 12-inch Douglas-fir planks. Fourteen 5-foot Black Hills ponderosa pine planks overlaid with experimental paper were also installed for service testing. The overlay, which was made at the Forest Products Laboratory, consisted of 0.018-inch thick kraft paper impregnated with 18 percent phenolic resin to match a commercial standard sold as medium-density overlay. The paper was cold pressed to the planks. Half of the planks were overlaid on both sides and half on one side only.

Figure U-8.--Stadium seats at the South Dakota School of Mines and Technology, Rapid City, South Dakota. Date of photograph, October 1, 1958.

After 1 year and 9 months of exposure, the material is performing satisfactorily (fig. U-9). The surfaces have remained smooth and almost free of checks or defects. Only minor delamination was noted. Weathering, checking, and cupping have also been moderate. Little difference was noted on the performance of planks overlaid on one or both sides. The cupping that did develop appeared to be related to the orientation of the annual rings rather than to the overlay. Similarly, the end checking that developed after installation did not appear to be any different in either type of construction. The checking did not progress after 6 months' exposure.

Figure U-9. --The spotty appearance of the overlaid plank is due to scuff marks made by a recent hailstorm. The Douglas-fir plank in the foreground is badly checked after 1 year and 9 months' exposure; whereas, the overlaid plank has remained free of surface checks. Date of photograph, June 23, 1960.

Pulp and paper mill under construction in Arizona

An important development in the field of forestry in the Southwest is the pulp and paper mill now under construction by the Southwest Forest Industries, Inc., near Snowflake, Arizona. The proposed combination kraft and groundwood mill (fig. U-10) will have an annual capacity of 75,000 tons of newsprint

and 65,000 tons of kraft linerboard and paper. Annual wood requirements are estimated at 236,000 cords. Approximately 145,000 cords will be supplied from mill residue and the remainder from roundwood, largely from national forest stumpage. Daily water requirements are estimated at 8 million gallons to be obtained from wells having a daily capacity of 20 million gallons.

The mill will cost in excess of $32 million and will provide employment for about 800 people. Production dates are October 1961 for the kraft mill and December 1961 for the newsprint.

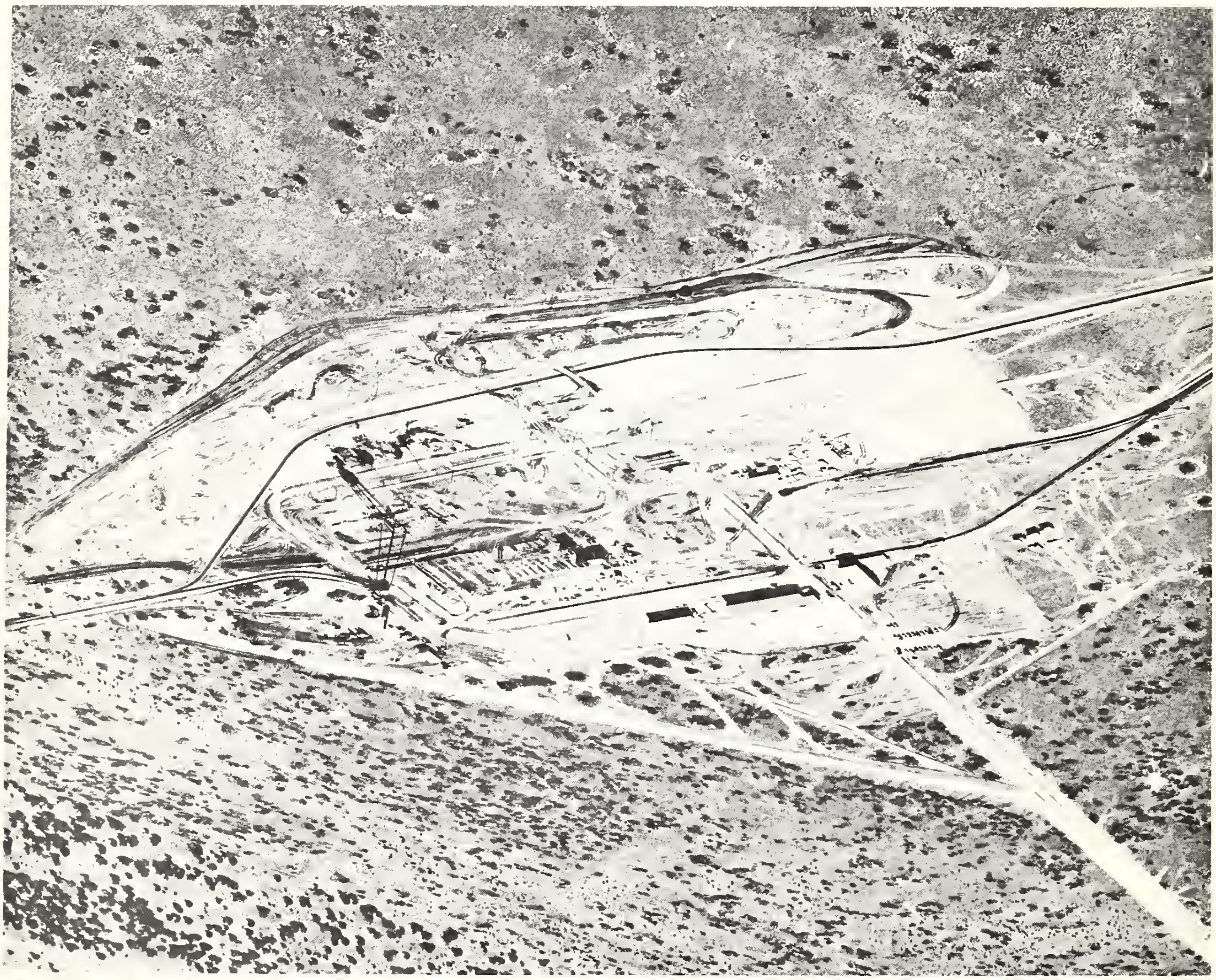
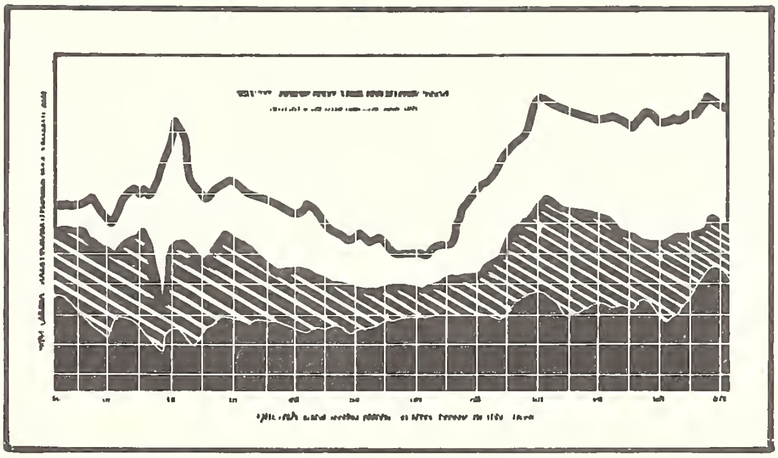


Figure U-10. --Aerial photograph of pulpmill under construction in Arizona. (Courtesy Southwest Forest Industries, Inc.)



Forest Economics Research

FOREST PRODUCTS MARKETING

Water study establishes benchmarks of pulpmill capacity in western Colorado

A cooperative study of water supply and how it might limit pulpmill capacity in western Colorado was completed (fig. E-1). The principal contributor was the U. S. Public Health Service. Stretches of streams studied were:

Colorado	Parshall to Kremmling Sweetwater to Dotsero New Castle to Rifle Grand Junction to Fruita
Eagle	Eagle to Gypsum
White	Buford to Meeker
Gunnison	Gunnison to Delta
North Fork Gunnison	Somerset to Hotchkiss

State water-pollution-control laws and regulations of the Colorado Department of Public Health and the Department of Game and Fish apply to pulpmill waste discharges. Because of these laws and regulations, wastes must not harm fish, settleable solids may not exceed 0.5 milliliter per liter, suspended

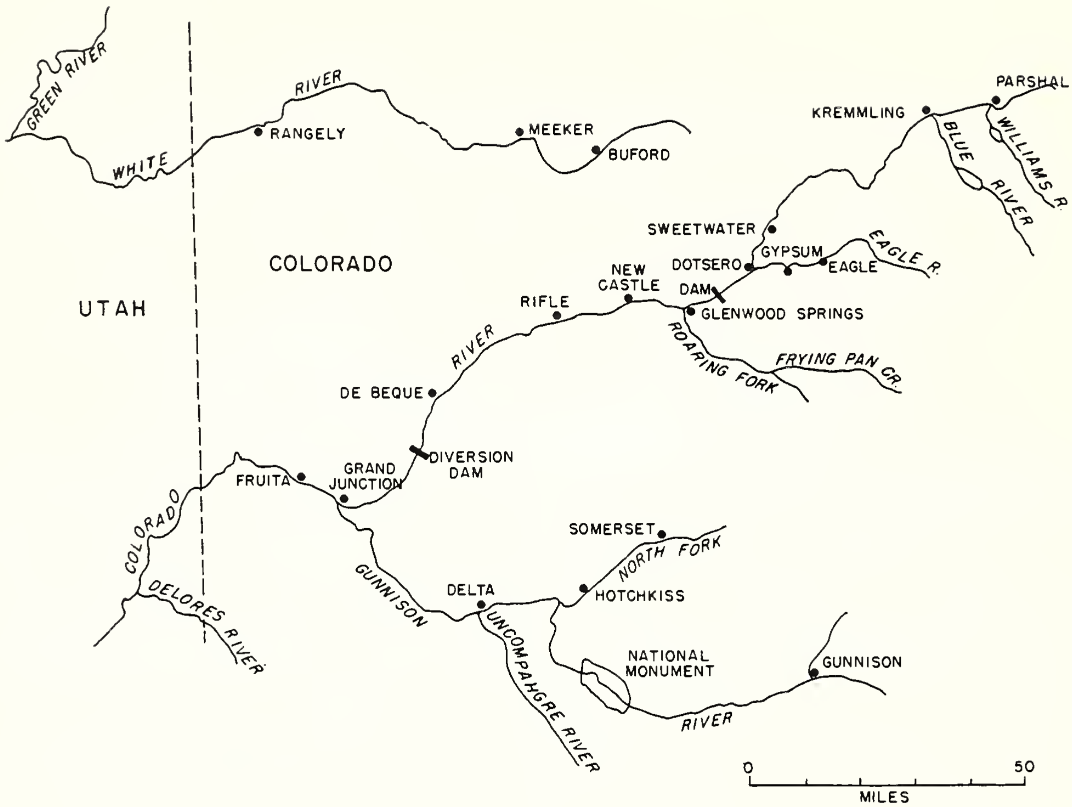


Figure E-1. --Streams studied in the potential pulpmill area

solids may not exceed 0.5 milliliter per liter, suspended solids may not exceed 75 parts per million, and 5-day, 20°C. biochemical oxygen demand may not exceed 50 parts per million. Downstream use for domestic water reduces the maximum permissible 5-day, 20°C. biochemical oxygen demand to 30 parts per million.

Table E-1. --Estimates of allowable mill capacity by pulping process and stream stretch

River and location	Pulping process		
	Sulfate	Semichemical	Groundwood[1]
	Tons of pulp a day		
Colorado:			
Near Kremmling	350	60	1,000+
Near Dotsero	600	110	1,000+
New Castle-Rifle	500	90	1,000+
Grand Junction-Fruita	400	75	1,000+
Eagle: Near Gypsum	0	0	1,000
White: Buford-Meeker	0	0	700
Gunnison: At Delta	0	0	600
North Fork Gunnison:			
Near Hotchkiss	0	0	700

[1] Unbleached. Bleaching may require reduction of capacity depending on degree of bleaching and processes used.

Allowable mill capacities were estimated for each of the designated stream stretches. These estimates (table E-1) are useful benchmarks to guide the pulp industry in developing the water resource.

The capacities indicated in table E-1 are mutually exclusive. For example, 350 tons a day of sulfate pulp production near Kremmling would exclude the production of semichemical and groundwood pulps at the same location. Estimates of product capabilities involving pulp combinations must be made separately. Approximations of maximum newsprint capacity based on a pulp mix of 75 percent groundwood and 25 percent sulfate are presented in the following tabulation:

Colorado River location	Tons of newsprint a day
Near Kremmling	1,030
Near Dotsero	1,765
New Castle-Rifle	1,470

Pulpwood procurement costs will be an important feasibility factor in pulpmill development

Pulpwood procurement costs made up of stump-to-truck costs, road-development costs, and pulpwood-hauling costs are key factors in analyzing the feasibility of pulpmill establishment along the Colorado River in western Colorado. In an area tributary to possible millsites along the Colorado River, stump-to-truck costs including felling, bucking, skidding, loading, general administration, depreciation, and profit will probably average between $8 and $10 a cord. This is comparable to similar costs in other areas presently producing pulp.

Hauling costs in the 10-million-acre tributary area are highly variable and depend principally upon hauling distance from stump to millsite. Hauling distances from various parts of the study area to the likely millsites along the Colorado River range from 10 to 400 miles. Truck hauling costs correspondingly range from $4 to $15 a cord for the wood in this area.

FOREST SURVEY

Timber inventory field work completed in Colorado, Wyoming, and Black Hills

The inventory of all volume sample plots on the Shoshone and Black Hills National Forests and on areas outside of national forests marked the completion of field work for area, volume, and growth data for Colorado, Wyoming, and the Black Hills.

Other phases of the Forest Survey nearing completion

The area-compilation phase of the Forest Survey in the central Rocky Mountains has been completed except for the Rio Grande, San Juan, Black Hills, and Medicine Bow (Laramie Peaks Division) National Forests. It is expected that some preliminary data on forest area and timber volumes will be available in the latter part of 1961.

Analysis of timber cut revealed a preliminary estimate of 44,200,000 cubic feet cut in Colorado in 1957, and 19,388,000 cubic feet cut in Wyoming the same year. The principal product in both States was saw logs (table E-2). Much of the volume in lower value products (fuelwood, farm timbers, and some posts) was cut from dead or noncommercial timber.

Table E-2. --Output of timber products in Colorado and Wyoming, 1957

Product	Colorado		Wyoming	
	M cu. ft.	Percent	M cu. ft.	Percent
Saw logs	34,416	77.9	18,198	93.9
Poles	514	1.2	128	.7
Posts	453	1.0	438	2.3
Mine timbers (round)	949	2.1	135	.7
Pulpwood	2,952	6.7	--	--
Excelsior bolts	2,383	5.4	--	--
Veneer logs (matchstock)	357	.8	--	--
Miscellaneous farm timbers [1]	373	.8	143	.7
Fuelwood [2]	1,756	4.0	338	1.7
Converter poles	47	.1	8	([3])
Total	44,200	100.0	19,388	100.0

[1] Mostly from dead timber.

[2] Practically all from dead or noncommercial timber; does not include mill residues used as fuelwood.

[3] Less than 0.1 percent.

Regional differences and product substitution noted in study of use of wood in residential housing

To provide information on national timber requirements, data were obtained on uses and substitutes for wood products in a sample of FHA-insured single-family housing units in Arizona, Colorado, Utah, and west Texas. Great differences in types of housing were observed between regions. Examples were the widespread use of both masonry and frame construction in Utah and Colorado, as compared with mostly frame in west Texas and almost all masonry in Arizona. There were almost no basements in Arizona and west Texas, but many new units in Colorado and Utah had basements. A recent major change in wood use in all the areas studied was found to be the substitution of plywood in place of lumber sheathing.

Range Management and Wildlife Habitat Research

SEMIDESERT AND SHRUB RANGES

More perennial grasses are fire killed when growing near shrubs

Perennial grasses growing in close association with burroweed (Haplopappus tenuisectus) and other shrubby species are much more severely damaged by controlled burning than those growing in the openings between shrubs. On a 100-acre June burn on the Santa Rita Experimental range in southern Arizona, Santa Rita three-awn (Aristida glabrata) increased 28 percent more in basal intercept on the burned area than on an unburned check area in the growing season immediately following burning (fig. R-1). This species suffered little damage from burning of light herbaceous fuel in openings between the shrubs. Santa Rita three-awn tends to be evenly dispersed with no observable association or disassociation with shrubby plants. In contrast, other species of three-awns (A. ternipes and A. hamulosa) characteristically grow within the burroweed crowns. These plants decreased 71 percent following the burn.

Arizona cottontop (Trichachne californica) and Rothrock grama (Bouteloua rothrockii) decreased 39 percent and 34 percent, respectively. These species are intermediate between Santa Rita three-awn and other three-awns with respect to degree of association with burroweed.

Aerial spraying of mesquite with 2,4,5-T pays

The value of increased perennial grass herbage resulting from aerial spraying mesquite-infested range for two successive years more than paid for the cost of the spraying. On the Santa Rita Experimental Range, three-fourths pound per acre 2,4,5-T was sprayed in two successive years in a cooperative

study with the U. S. Agricultural Research Service. Because there was so little grass prior to spraying, Lehmann lovegrass (Eragrostis lehmanniana) was seeded at the time of the first application of 2, 4, 5-T (fig. R-2).

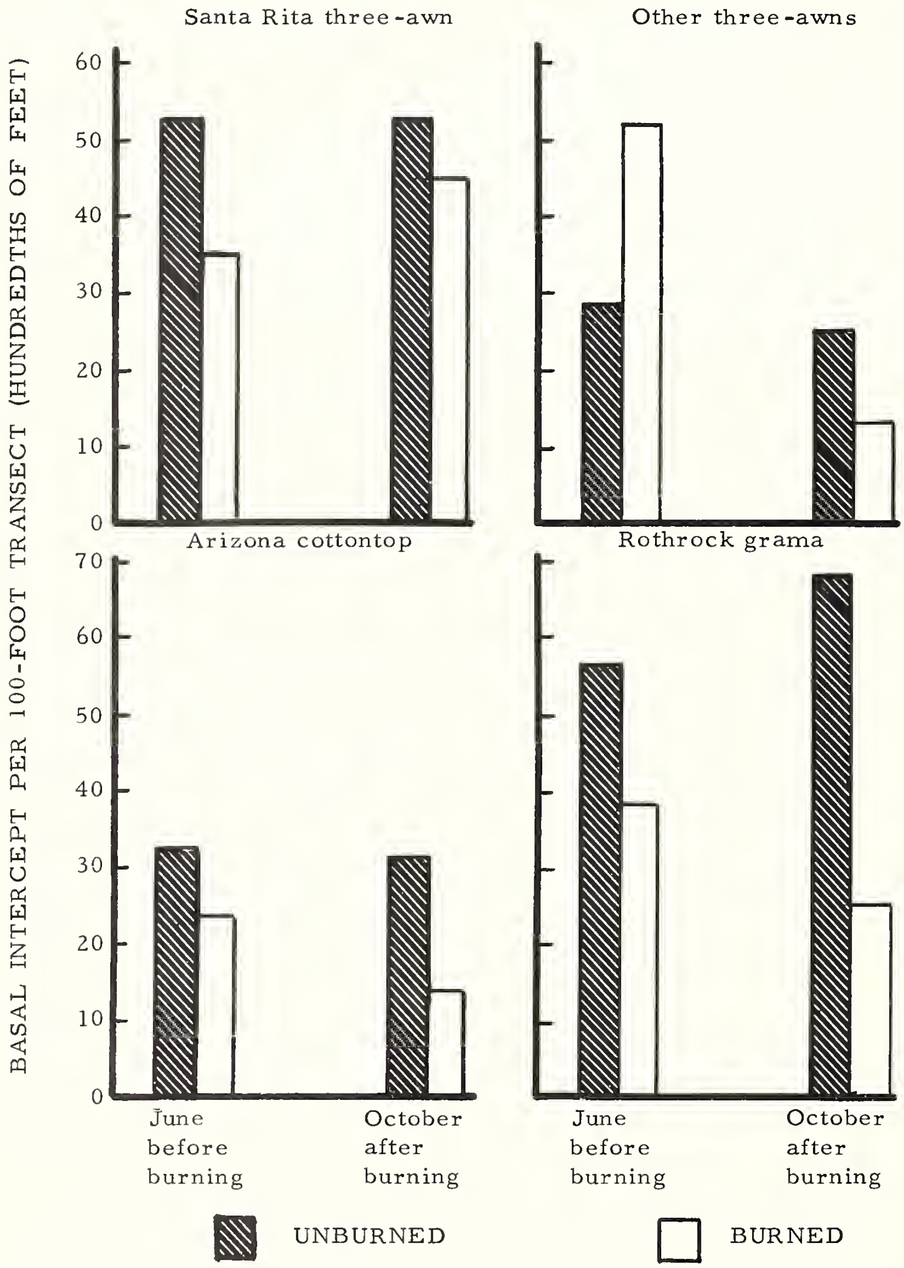


Figure R-1. --Changes in basal intercept of important grass species resulting from burning on the Santa Rita Experimental Range.

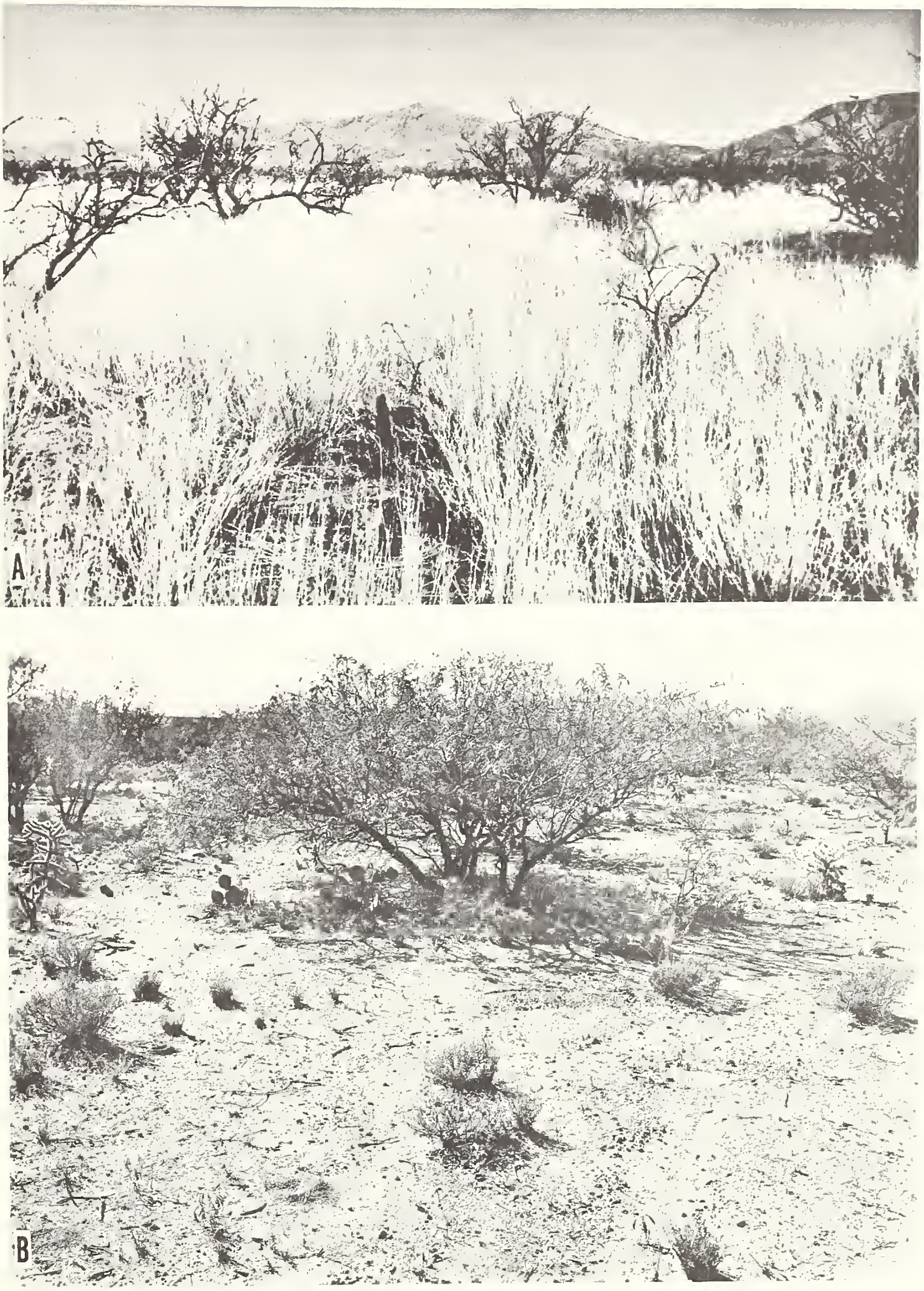


Figure R-2.--A, Excellent perennial grass herbage production on area sprayed to control mesquite and seeded to Lehmann lovegrass; B, adjacent unimproved range.

Cost of each of the spraying treatments was $3.50 per acre ($1.50 for 2,4,5-T, $0.75 for diesel oil, $1.25 for airplane). Cost of the seeding was $3.00 per acre ($2.00 for seed and $1.00 for airplane). Sufficient grass was produced to repay the cost of both spraying and seeding the year following the second herbicide application (fig. R-3). Cost of seeding alone was repaid at the end of the third year.

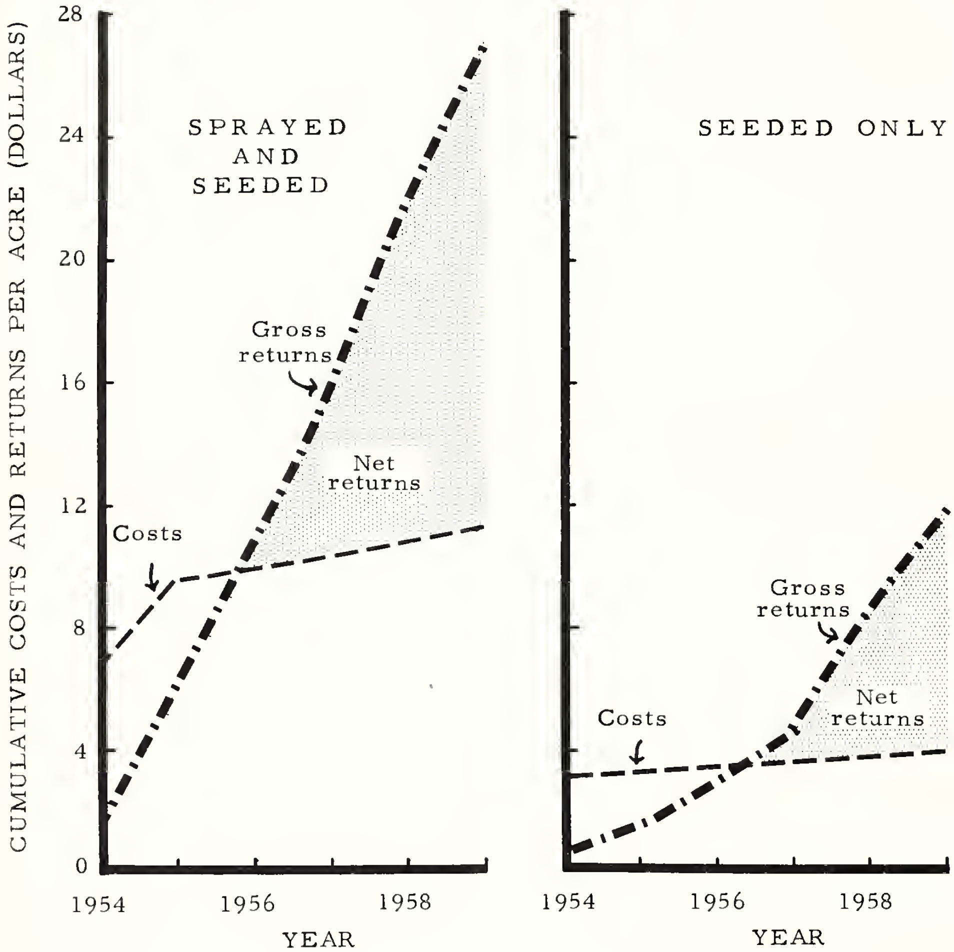


Figure R-3.--Cumulative costs of seeding and spraying mesquite-infested range and cumulative returns based on the following assumptions:

(1) Fifty percent of the total herbage produced is usable forage.
(2) A cow consumes 20 pounds of air-dry forage a day.
(3) A cow-day of grazing produces 1 pound of salable beef.
(4) The net selling price of range beef is 20 cents a pound.
(5) The interest rate on the capital invested is 4 percent.

The mesquite canopy was reduced about 95 percent by the two herbicide treatments. The extremely slow rate of mesquite recovery indicates that the beneficial effects will continue for several more years. The native perennial

grasses, particularly Arizona cottontop, responded much more quickly to the release from mesquite competition than did the seeded lovegrass. Air-dry weight of native perennial grasses averaged 581 pounds per acre on the sprayed area during the 6 years since the first spraying, versus 294 pounds per acre on the adjacent unsprayed area. Lehmann lovegrass averaged 240 pounds per acre on the sprayed area, or three times the average of the unsprayed area.

Shrub and grass cover related to soil type

Velvet mesquite (_Prosopis juliflora_ var. _velutina_) and burroweed have increased much more on sandy soil with low clay content, such as the Comoro and Sonoita series, than on heavier soils with a clay subsoil, such as the Whitehouse series, on the Santa Rita Experimental Range (figs. R-4 and R-5). Velvet mesquite and burroweed covered 77 percent of the ground on plots located on the Comoro and Sonoita soils, but only 7 percent on plots of the Whitehouse soils located in the same pastures. Important plants on the Whitehouse series were calliandra (_Calliandra eriophylla_) and several gramas (_Bouteloua_ spp.). On the Comoro and Sonoita series important plants were velvet mesquite, burroweed, Arizona cottontop, tanglehead (_Heteropogon contortus_), three-awns (_Aristida_ spp.), and bush muhly (_Muhlenbergia porterii_).

Observations on the soils lead to the conclusions that, under yearlong grazing, grass composition on the Whitehouse soils changes from predominantly tall grasses, such as Arizona cottontop, tanglehead, and three-awns, to lower growing species, such as sprucetop and slender gramas (_Bouteloua chondrosioides_ and _B. filiformis_). On the Comoro soils, when the taller grasses disappear from the openings between the shrubs, they are not replaced by the low-growing perennial grasses.

Mesquite seedlings sprout after burning

One-third of 8- and 12-month-old mesquite seedlings survived grass fires on the Santa Rita Experimental Range. Most of the surviving seedlings were top-killed and sprouted later from the base, even though they were only 4 to 6 inches tall when burned. A few seedlings survived the burn without the tops being killed. The seedling survival was the same for the 8-month-old plants as for the 12-month-old plants.

The seedlings used in the study were started in the greenhouse in July and transplanted into dense, established grass stands 1 month later. The grass and mesquite seedlings were then burned in February when the seedlings were 8 months old and in June when 12 months old.

Figure R-4. --Changes in cover on Whitehouse soil. A, The area in 1918 had little grass and a few scattered mesquite trees. B, In 1959, there was more grass and the mesquites are larger, but the trees are still widely spaced. Mesquites in the background are on other soil types.

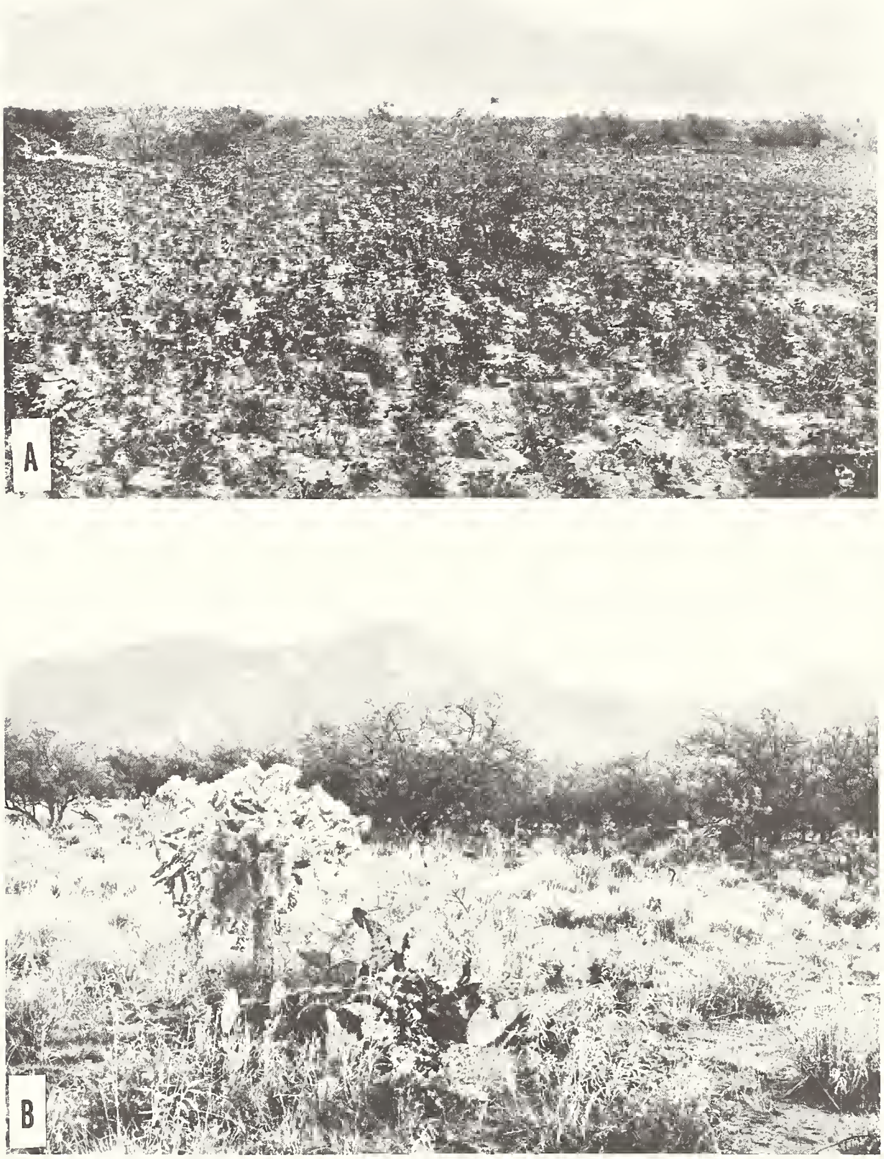


Figure R-5. --Changes in cover on Comoro soil. A, The area in 1919 supported primarily grasses and forbs, with a few scattered mesquite trees. B, By 1959 mesquite completely occupied the site except for the foreground area from which the trees were cleared in 1935.

Utilization estimates by plant-count method requires care in field use

Analysis of the plant-count method of determining utilization of perennial grasses by cattle at the Santa Rita Experimental Range in southern Arizona showed that different species on the same range differ in their relationship between percent utilization and the percent of plants grazed. The differences may be large enough that separate relationships should be developed for different species. However, some species tend to group so that using a generalized curve for several species may be feasible without introducing too large an error.

The relationship for curlymesquite (Hilaria belangeri) was distinctly different from the other four species studied: Arizona cottontop, black grama (Bouteloua eriopoda), slender grama, and Santa Rita three-awn (table R-1). Statistical analysis also showed the difference between some of the other species is real and consistent, although the amount is not so great as between curlymesquite and the other grasses individually or as a group.

The relationship between percent of plants grazed and percent utilization for a species varied somewhat between years, but the variation was not large enough to require separate cuves each year for four of the five species studied. Curlymesquite was the only species on which the use of the average relationship would have caused an error that exceeded 6.5 percent utilization when the utilization is 50 percent.

Table R-1.--Regression coefficients[1] and percent utilization by weight in year when regression coefficient was highest and lowest compared with the average relationship

Species	Type of year	Regression coefficients	Plants grazed				
			10%	25%	50%	75%	90%
			Percent utilization by weight				
Arizona cottontop	Average	0.7109	7.1	17.8	35.5	53.3	64.0
(Trichachne californica)	High	.7504	7.5	18.8	37.5	56.3	67.5
	Low	.6762	6.8	16.9	33.8	50.7	60.9
Slender grama	Average	.7098	7.1	17.7	35.5	53.2	63.9
(Bouteloua filiformis)	High	.7898	7.9	19.7	39.5	59.2	71.1
	Low	.6670	6.7	16.7	33.4	50.0	60.0
Santa Rita three-awn	Average	.6468	6.5	16.2	32.3	48.5	58.2
(Aristida glabrata)	High	.7333	7.3	18.3	36.7	55.0	66.0
	Low	.5780	5.8	14.4	28.9	43.4	52.0
Black grama	Average	.6211	6.2	15.5	31.1	46.6	55.9
(Bouteloua eriopoda)	High	.6718	6.7	16.8	33.6	50.4	60.5
	Low	.5820	5.8	14.6	29.1	43.6	52.4
Curlymesquite	Average	.3672	3.7	9.2	18.4	27.5	33.0
(Hilaria belangeri)	High	.5471	5.5	13.7	27.4	41.0	49.2
	Low	.3232	3.2	8.1	16.2	24.2	29.1

[1] Regression of percent utilization by weight over number of plants grazed expressed as percent.

Production of weeping lovegrass inversely related to amount of oak brush

Production and basal area of weeping lovegrass (Eragrostis curvula) 2 years after seeding continues to increase in inverse proportion to the relative amount of crown canopy of shrub live oak (Quercus turbinella)(fig. R-6). All species of shrubs except shrub live oak were killed on small plots near Globe, Arizona, in 1957, and the crown canopy of the oak was altered to give canopy classes at 10 intervals from zero to 100 percent of the maximum crown cover found on the area. In 1958, production ranged from 725 pounds per acre, air dry, under 10 percent oak canopy to 175 pounds under 100 percent oak canopy. In 1959 production under the two extremes in amount of oak canopy ranged from 1,839 pounds to 252 pounds. Basal area of weeping lovegrass varied from 2.05 percent to 0.37 percent under oak canopy classes of 10 to 100 percent.

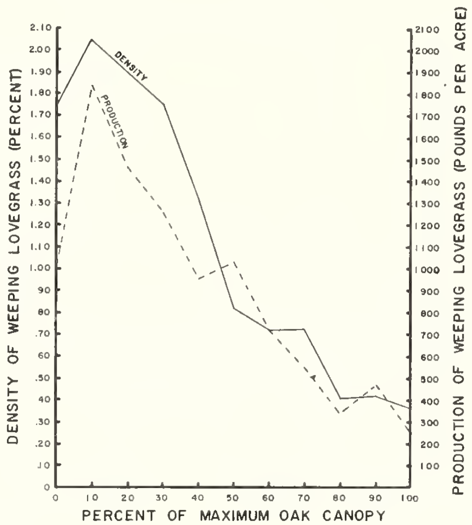


Figure R-6.--Relationship between percent crown canopy of shrub live oak and basal area and herbage production of weeping lovegrass (1959).

Perennial grass response following shrub control differs with soil type

Basal area of perennial grasses growing on soils derived from quartzite responded more to release from brush competition than on soils derived from diabase in the chaparral of central Arizona (table R-2). The increase of grass herbage production, however, was greater on diabase soils. In 1959, 5 years after basal spraying the brush with a mixture of 2,4-D and 2,4,5-T in a diesel

oil carrier, the grasses on treated areas produced 304 pounds per acre air-dry on quartzite and 259 pounds on diabase. Conversely, grasses on untreated areas produced 151 pounds per acre air-dry on quartzite and 51 pounds on diabase.

Table R-2.--Basal area of perennial grasses on two soils of the chaparral before and after shrub control

Year	Quartzite soil		Diabase soil	
	Shrubs controlled	No control	Shrubs controlled	No control
	Feet intercept per 100 feet of transect			
1954 (pretreatment)	0.203	0.349	0.205	0.411
1959 (after treatment)	.664	.265	.265	.241

MOUNTAIN RANGES

Native plants contain growth inhibitors

Twenty native plant species collected in northern Arizona contain substances that retarded the growth of wheat radicles (fig. R-7, table R-3).

Figure R-7.--Wheat seedlings with average length radicles grown on extract of Utah juniper and on distilled water.

Table R-3.--Growth of wheat radicles in various plant extracts compared with growth of radicles in water[1]

Plant species	In water extract	In 50% ethyl alcohol extract[2]	In 100% ethyl alcohol extract[2]
		- - - - - Percent - - - - -	
TREES			
Pinyon (Pinus edulis)	33	23	35
Ponderosa pine (P. ponderosa)	14	6	25
Alligator juniper (Juniperus deppeana)	17	11	35
One-seed juniper (J. monosperma)	21	10	15
Utah juniper (J. osteosperma)	15	5	17
Gambel oak (Quercus gambelii)	38	22	56
SHRUBS AND HALF-SHRUBS			
Fringed sagebrush (Artemisia frigida)	23	8	36
Big sagebrush (A. tridentata)	9	3	16
Cliffrose (Cowania mexicana)	8	5	40
Snakeweed (Gutierrezia sarothrae)	27	16	51
Hairless bitterweed (Hymenoxys rusbyi)	21	28	30
Shrub live oak (Quercus turbinella)	44	19	41
FORBS			
Thistle (Cirsium spp.)	5	9	45
Wright birdbeak (Cordylanthus wrightii)	2	1	8
Alfileria (Erodium cicutarium)	29	26	75
Annual goldeneye (Viguiera annua)	22	8	52
Mullein (Verbascum thapsus)	22	--	--
GRASSES			
Western wheatgrass (Agropyron smithii)	32	34	64
Cheatgrass (Bromus tectorum)	34	19	53
Squirreltail (Sitanion hystrix)	30	23	52

[1] Each percentage is the sum of radicle lengths from 200 seeds placed in the extract, measured at 48 hours, divided by the sum of radicle lengths from 200 seeds placed in distilled water × 100.

[2] Alcohol extracts were dried on filter paper, then rewet with water.

This was determined by making germination tests on filter paper moistened with extracts of plant material. Five grams of plant material were used in 100 ml. of solvent. Such growth inhibitors in plants could result in chemical antagonism between plants. For example, the inhibitors in juniper may help to reduce the understory vegetation under juniper trees when the leaves and twigs fall to the ground.

Intensity for spring grazing of crested wheatgrass recommended

Crested wheatgrass (Agropyron cristatum) in northern New Mexico withstood 65 to 70 percent utilization (by weight) 1 month each spring for 7 years of grazing without impairing herbage production. This utilization was measured at the time the cattle were removed, and summer rains produced subsequent growth in most years. At this intensity the stands were maintained and cattle gains were satisfactory.

Best spring use on crested wheatgrass with flexible stocking

Considerable flexibility in stocking rates is necessary for efficient spring grazing of seeded crested wheatgrass range in northern New Mexico because herbage production varies greatly with fluctuations in precipitation (table R-4). For example, average stocking rates on two experimental areas ranged from about 4 acres per animal month when precipitation for the preceding October-March period was 2-4 inches to about 2 acres per animal month when it was 6-8 inches.

Table R-4.--Herbage yield of crested wheatgrass on two experimental areas in northern New Mexico

Site and pasture	1952	1953	1954	1955	1956	1957	1958	1959
	Pounds per acre, air-dry							
Cebolla Mesa:								
Lightest grazed	335	460	791	589	96	624	718	436
Medium grazed	270	310	616	457	71	605	588	366
Heaviest grazed	189	251	551	507	69	447	503	318
No grazing	--	--	--	--	58	476	573	289
No Agua:								
Lightest grazed	--	--	--	839	109	615	768	663
Medium grazed	--	--	--	893	116	649	762	672
Heaviest grazed	--	--	--	770	60	728	593	778
No grazing	--	--	--	--	54	608	746	637

Herbage available to the cattle also may be altered appreciably by cool, wet weather or hot, dry weather during the spring grazing period. Because of these weather variations, year-to-year variation in degree of use must be expected even when the best possible estimate of herbage production is made before the cattle are turned on to the range.

Cattle gains are good on crested wheatgrass

At Cebolla Mesa in northern New Mexico, weight gains of cows during 1 month of spring grazing on crested wheatgrass averaged higher under the lightest grazing than under the medium or heaviest grazing intensities. However, even under the heaviest grazing intensity, cows made sufficient gains to put them in good breeding condition. There were no material differences in weight gains of calves due to different grazing intensities during the 1953-58 study period :

Grazing intensity	Average utilization (Percent)	Weight gain	
		Cows	Calves
		(Pounds)	
Heaviest	69	95	74
Medium	55	112	74
Lightest	41	145	81

Fragmentation and size of crested wheatgrass plants related to grazing intensity

Large crested wheatgrass plants are fragmented into a number of smaller plants through grazing. In north-central New Mexico, under three intensities of grazing and no grazing, the number of plants per unit area generally increased with heavier grazing, but basal diameter of the individual plants decreased:

Grazing treatment	Plants per plot (9.6 sq. ft.)		Basal diameter	
	Cebolla Mesa	No Agua	Cebolla Mesa	No Agua
	(Number)	(Number)	(Inches)	(Inches)
Not grazed	9.5	7.0	2.9	2.0
Lightest grazed	14.9	12.0	2.6	1.4
Medium grazed	16.6	14.2	2.0	1.3
Heaviest grazed	17.9	12.1	1.6	1.4

The number of weak plants was found to be proportional to the intensity of grazing. Weakened plants were replaced by young plants on all pastures except the heaviest grazed pasture at No Agua. This pasture was grazed at an average intensity of 77 percent utilization for 4 years and weak or dying plants were numerous; whereas young plants were scarce. Herbage production was not adversely affected by the change in structure of the grass stands under any of the treatments.

Weight of crested wheatgrass plants determined from crown diameter and plant height

Weight of crested wheatgrass plants was found to be closely related to the diameter of the compressed crown measured midway between the tallest and shortest leaf collars, basal diameter, and distance from the ground to the tallest leaf collar when the foliage and culms were raised to the maximum vertical position. Analysis of these measurements on crested wheatgrass in northern New Mexico gave a multiple correlation coefficient of $R = 0.922$. The regression equation for the relationship was

$$Y \doteq -26.240 + 2.148X_1 + 22.872X_2 + 1.900X_3$$

where

X_1 = basal diameter,
X_2 = compressed crown diameter,
X_3 = leaf length,
Y = ovendry weight of plant material.

This suggests the possibility of estimating herbage production of crested wheatgrass by measuring the height, diameter, and density of plants.

Rotation grazing shows promise for more efficient use of mountain ranges

Utilization of upland grassland areas increased and utilization of meadows decreased when summerlong grazing was changed to rotation grazing on the Green Mountain Cattle Allotment, Medicine Bow National Forest, Wyoming (fig. R-8). Ordinarily, cattle concentrate on and overgraze the meadows. In 1957, angus cattle grazed the Green Mountain Allotment seasonlong as one large range 9,350 acres in area. In 1958 and 1959 the allotment was subdivided into four units and the same number and kind of cattle grazed, but the time of grazing in the units rotated. The relation between use of the grassland and meadows was much the same in all 3 years on the adjacent allotment which was grazed seasonlong all 3 years as a check.

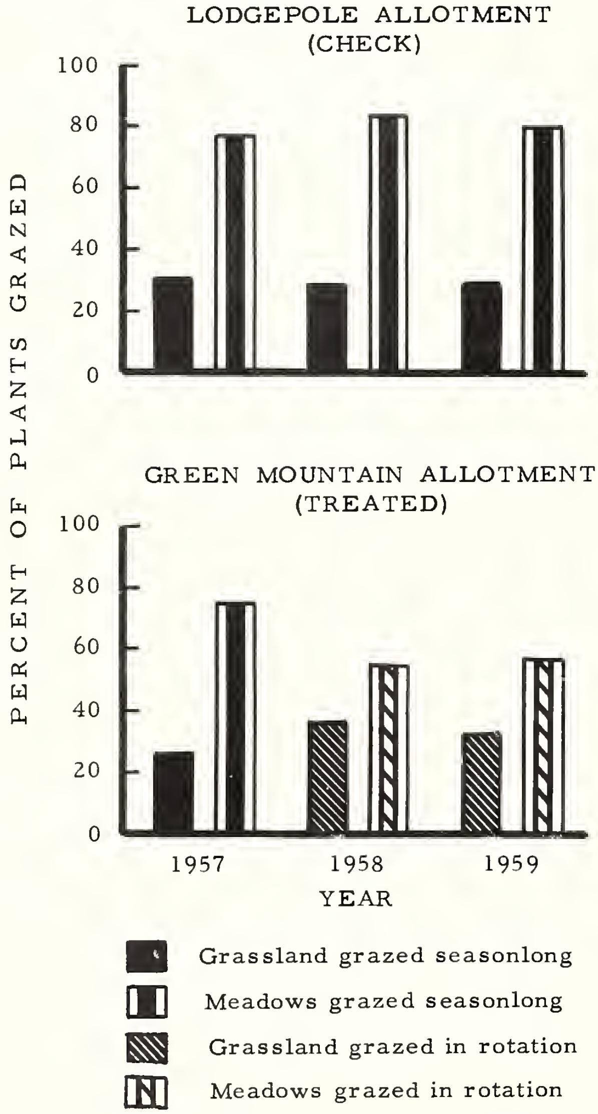


Figure R-8.--Average utilization of the grassland and meadow types. Utilization was determined by using the percent of plants grazed of the two most abundant grass or grasslike plants found at each site.

Method of classifying range condition suggested

A range-condition classification scheme for grassland openings in ponderosa pine ranges of the Front Range of the Rocky Mountains was developed from known conditions that resulted from grazing at different intensities for many years at the Manitou Experimental Forest.

Herbage production of the desirable grasses on the range in relation to the maximum possible production was used as the criteria for classifying range condition. Four classes were recognized:

Excellent condition --	Range producing 76 to 100 percent of maximum
Good condition --	51 to 75 percent
Fair condition --	26 to 50 percent
Poor condition --	25 percent or less

The regression equation $E = 8.77X_1 + 3.61X_2 - 134.63$ was developed for the relationship between total herbage production of the desirable grasses (E) and measurements made with the loop-transect method commonly used for measuring range condition and trend on national forests. In this equation X_1 is the percentage of 3/4-inch loop observations with desirable grasses; X_2 is the ratio (in percent) of the average maximum leaf height of mountain muhly on the area being studied to the average maximum leaf height of mountain muhly in good vigor the same year. The multiple correlation coefficient of this relationship is $R = 0.893$. A chart based on this equation has been developed as a possible aid in judging range condition (fig. R-9).

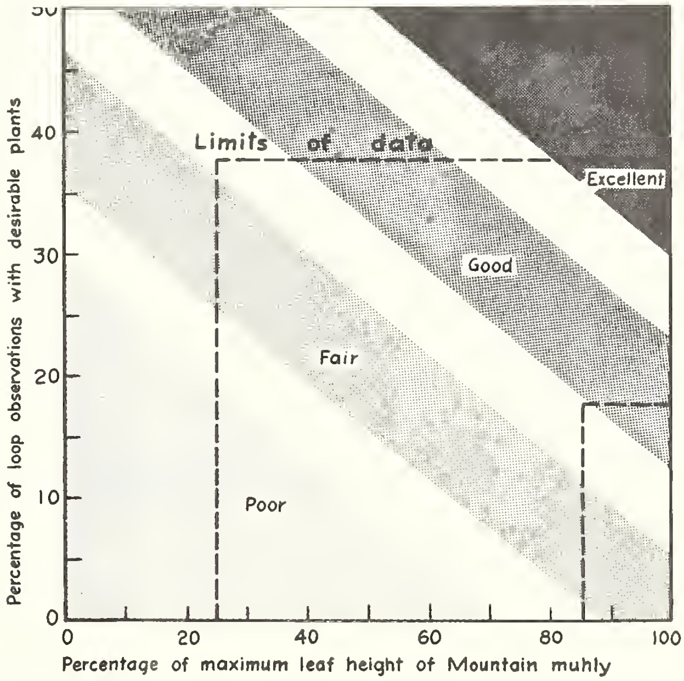


Figure R-9.--Range-condition classification for grassland openings in ponderosa pine ranges, Front Range of the Rocky Mountains. (White bands between classes represent the standard error of estimate.)

Idaho fescue production influenced by grazing intensity

Cattle grazing at three different intensities for 7 years on grassland range in the Big Horn Mountains, Wyoming, resulted in differences in herbage production, particularly of Idaho fescue (Festuca idahoensis), the major forage species. Average production of Idaho fescue in 1959, the year after the grazing treatments were discontinued, was as follows for the two main soils found in the study area:

	Heavy	Moderate	Light
	(Pounds per acre, air-dry)		
Soils derived from granite	81	127	188
Soils derived from sedimentary rocks	154	228	307

Idaho fescue was producing at least twice the herbage on the lightly grazed (25 percent utilization by height) range as on the heavily grazed (75 percent utilization by height) range. The moderately grazed (50 percent utilization by height) range produced Idaho fescue in intermediate amounts. This study was in cooperation with the University of Wyoming.

Rotation grazing apparently best

In the first 2 years of comparisons, rotation grazing outproduced season-long grazing on the Big Horn Mountains, Wyoming. At the same time, it lessened the intensity of grazing on the major forage plant, Idaho fescue. Three methods of grazing are being compared in a cooperative study with the University of Wyoming:

1. Summerlong grazing at a moderate rate (enough cattle to give 50 percent utilization of Idaho fescue);
2. A three-pasture rotation at a moderate rate;
3. A three-pasture rotation at a heavy rate (50 percent more cattle per acre than the moderate rate).

Cattle gains for the first 2 years of the study are as follows:

		1959	1960
		(Animal days per acre)	
Stocking --			
Moderate rate:	Summerlong	23.8	29.2
	Rotation	22.5	27.2
Heavy rate:	Rotation	32.6	38.3
		(Pounds per steer)	
Average daily gains --			
Moderate rate:	Summerlong	1.86	1.92
	Rotation	2.26	2.13
Heavy rate:	Rotation	1.89	1.77

The average utilization of Idaho fescue resulting from the treatments was as follows:

		1959	1960
		(Percent utilization)	
Soils derived from granite --			
Moderate rate:	Summerlong	36	42
	Rotation	11	15
Heavy rate:	Rotation	22	41
Soils derived from sedimentary rocks --			
Moderate rate:	Summerlong	52	72
	Rotation	16	33
Heavy rate:	Rotation	28	41

Clipping reduces cover of native grasses and sedges

Clipping to a 1-inch stubble height once every 2 weeks during the four consecutive summers greatly reduced the cover of tufted hairgrass (*Deschampsia caespitosa*), redtop (*Agrostis alba*), and sedges (*Carex* spp.) in the Bighorn National Forest of Wyoming (table R-5). Clipping to a 3-inch height has less effect on the sedges and no appreciable effect on the grasses. There was also a shift from white clover (*Trifolium repens*) to Kentucky bluegrass (*Poa pratensis*), which was not related to clipping treatments.

Table R-5.--Effect of three intensities of clipping on cover of some major species in the Bighorn National Forest, Wyoming

Species	Clipped to 1-inch height		Clipped to 3-inch height		Check	
	1952	1956	1952	1956	1952	1956
	Percent					
Kentucky bluegrass (*Poa pratensis*)	8.4	21.5	13.2	25.7	11.3	24.1
Tufted hairgrass (*Deschampsia caespitosa*)	16.2	5.3	14.3	18.2	11.0	13.5
Redtop (*Agrostis alba*)	5.4	0.7	6.0	5.0	5.3	4.7
Sedges (*Carex* spp.)	21.9	4.0	19.1	11.5	21.3	18.7
Other grasses and grasslike plants	8.6	4.2	8.6	5.3	13.6	9.3
White clover (*Trifolium repens*)	20.3	0	15.2	1.5	19.0	1.3
Other forbs	3.6	4.3	5.6	6.2	3.4	9.4
Total	84.4	40.0	82.0	73.4	84.9	81.0

Range in good condition responds to herbicides

Spraying with 2,4-D in 1959 resulted in spectacular changes in plant composition and forage production on mountain bunchgrass range in good condition in western Colorado (fig. R-10).

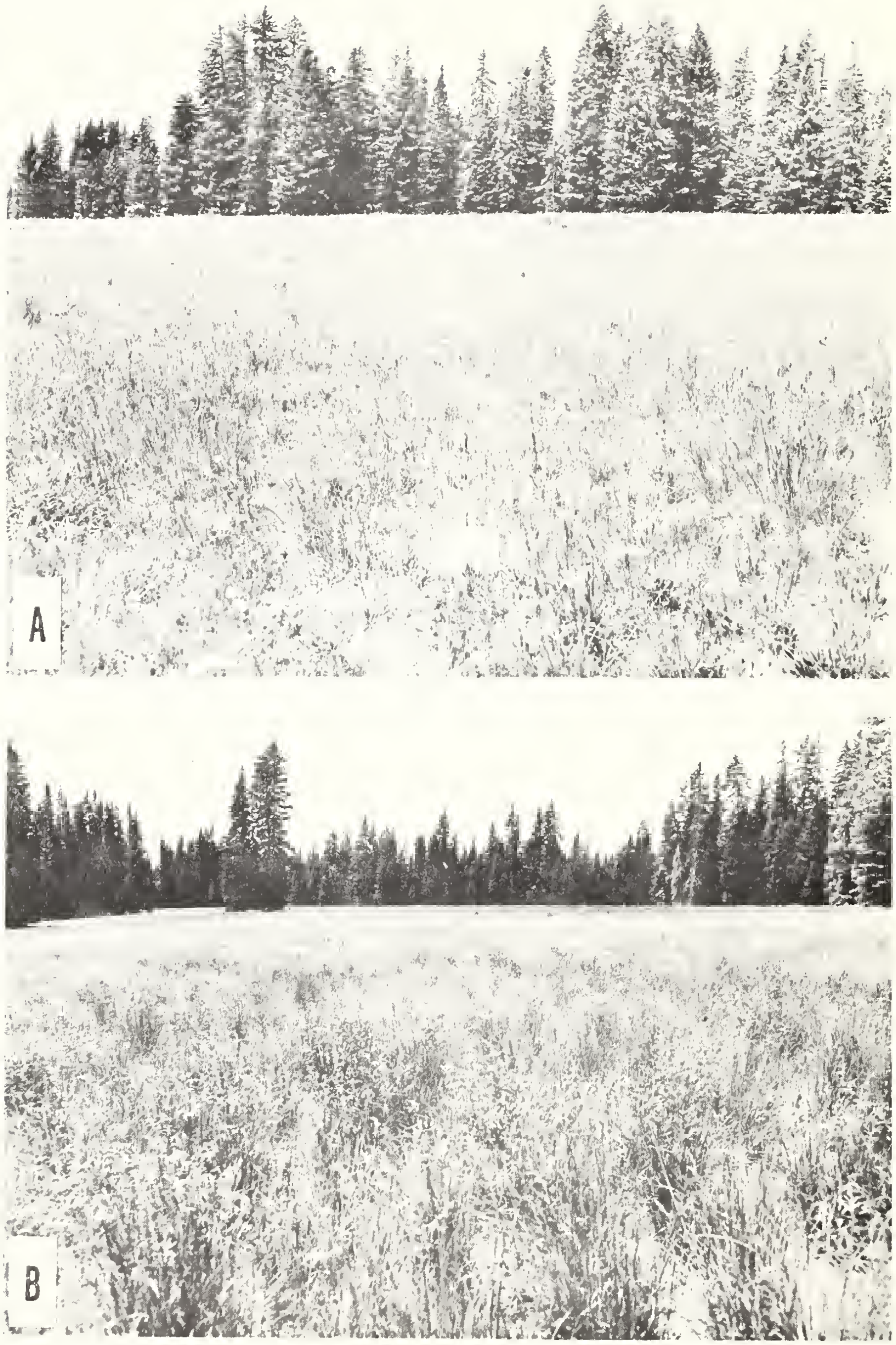


Figure R-10.--A, Untreated range on Black Mesa produced about 800 pounds of herbage per acre in 1960. Of this, 56 percent was grasses and 44 percent was forbs. B, Range treated in 1959 with 2,4-D produced almost 1,800 pounds of forage per acre in 1960. Of this, 96 percent was grasses and 4 percent was forbs.

In 1960 grass production on sprayed range averaged 1,719 pounds (air-dry) per acre, while on similar untreated range grasses produced only 445 pounds per acre. Forbs produced 72 pounds per acre on sprayed range and 345 pounds per acre on untreated areas. Before treatment these areas had about the same plant composition. Herbage production in 1960 by species is shown below:

	Treated	Untreated
	(Pounds per acre, air-dry)	
Grasses:		
Slender wheatgrass (*Agropyron trachycaulum*)	347	85
Nodding brome (*Bromus anomalus*)	62	2
Idaho fescue (*Festuca idahoensis*)	32	11
Thurber fescue (*F. thurberi*)	1,101	304
Subalpine needlegrass (*Stipa columbiana*)	67	4
Letterman needlegrass (*S. lettermanii*)	32	28
Others (3 species)	78	11
Total	1,719	445
Forbs:		
Western yarrow (*Achillea lanulosa*)	Trace	17
Agoseris (*Agoseris* spp.)	--	19
Aspen fleabane (*Erigeron macranthus*)	1	34
Fremont geranium (*Geranium fremontii*)	64	71
Aspen peavine (*Lathyrus leucanthus*)	3	15
Porter ligusticum (*Ligusticum porteri*)	--	116
Beauty cinquefoil (*Potentilla pulcherrima*)	--	14
Others (14 species)	4	59
Total	72	345

Ranges were sprayed in cooperative studies by the Fish and Wildlife Service, U. S. Department of the Interior. Herbicide in a water emulsion was applied at the rate of 3 pounds acid equivalent per acre.

High-elevation sheep ranges classified in Wyoming

Preliminary classification and description of the major types in Wyoming was completed from a survey during the summer of 1959 (fig. R-11). This survey furnished essential background information for more intensive research in management of these important sheep ranges.

Table R-6.--Major types on high-altitude sheep ranges, Wyoming

Type name and principal species	Extent	Grazing value	Site characteristics	Effects of overuse
ALPINE				
Fescue-Primula: Festuca Primula Caltha	Not frequent	Minor	Frost churning and rock polygons	A pioneer stage of succession. Grazing could delay development of advanced stages of succession
Willow: Salix Carex Deschampsia	Not frequent	Moderate productivity	Wet sites below snowfields, bottoms, and bogs	Site desiccation usually with erosion. Juncus and cushion plants become important
Sedge-hairgrass turf: Carex Deschampsia Poa Trifolium	Widely distributed	High productivity and capacity	Moist to dry sites	Decrease of principal species. Increase of Geum and mat or cushion plants on dry sites. Increase of Geum, Antennaria, Agrostis, Sibbaldia procumbens on moist sites
SUBALPINE				
Open parks: Carex Deschampsia Forbs	Widely distributed	High productivity and capacity	Moist sites near timberline	Decrease of principal species. Increase of Geum, Antennaria, Agrostis.
Wet meadows: Carex Deschampsia Trifolium Polygonum	Frequent--usually small areas widely distributed	Highly productive but usually too wet for grazing	Depressions with abundant water	Site desiccation, usually with erosion
Grassland slopes: Festuca Poa Agropyron	Limited--principally to Big Horn Mountains	High productivity and capacity	Well-drained slopes below timberline drier sites	Decrease of palatable grasses, sedges, and forbs. Festuca idahoensis, Antennaria, and Erigeron remain
Moderate timber: Vaccinium Arnica cordifolia	Widely distributed	Minor		Development of trailing damage principally
Dense timber: Little herbaceous understory	Widely distributed	None		Not grazed

Watershed Management Research

Evaporation from snow rather small in Arizona and New Mexico

Figure W-1. --Evaporation from snow being measured in a pine stand in Arizona. Differences in weight of snow-filled pan from 8 a.m. to 5 p.m. indicated snow evaporation. Losses ranged from 0.006 inch to 0.016 inch. In New Mexico under aspen cover, evaporation loss on north slopes was 0.008 inch and 0.014 inch on south slopes. Maximum night (5 p.m. to 8 a.m.) condensation values in New Mexico were 0.004 inch on a north slope and 0.002 inch on a south slope.

Studies such as these help provide an understanding of the importance of snow evaporation and condensation from different forest types and aspects.

Creep and settlement active in alpine snowpack

The settlement and creep of snow on steep mountain slopes induces or relieves stresses contributing to avalanches. It also bends and deforms trees buried by snow. Snow movements are described in our Research Note 43.

Creep, the result of downslope motion, varied between 0.7 inch and 1.2 inches per foot of snow for short slopes with grades of 20 to 56 percent. Settlement, the vertical shrinkage of the snow resulting from changes in the size and shape of individual snow crystals, varied from 2 inches to 3.3 inches per foot of depth (fig. W-2).

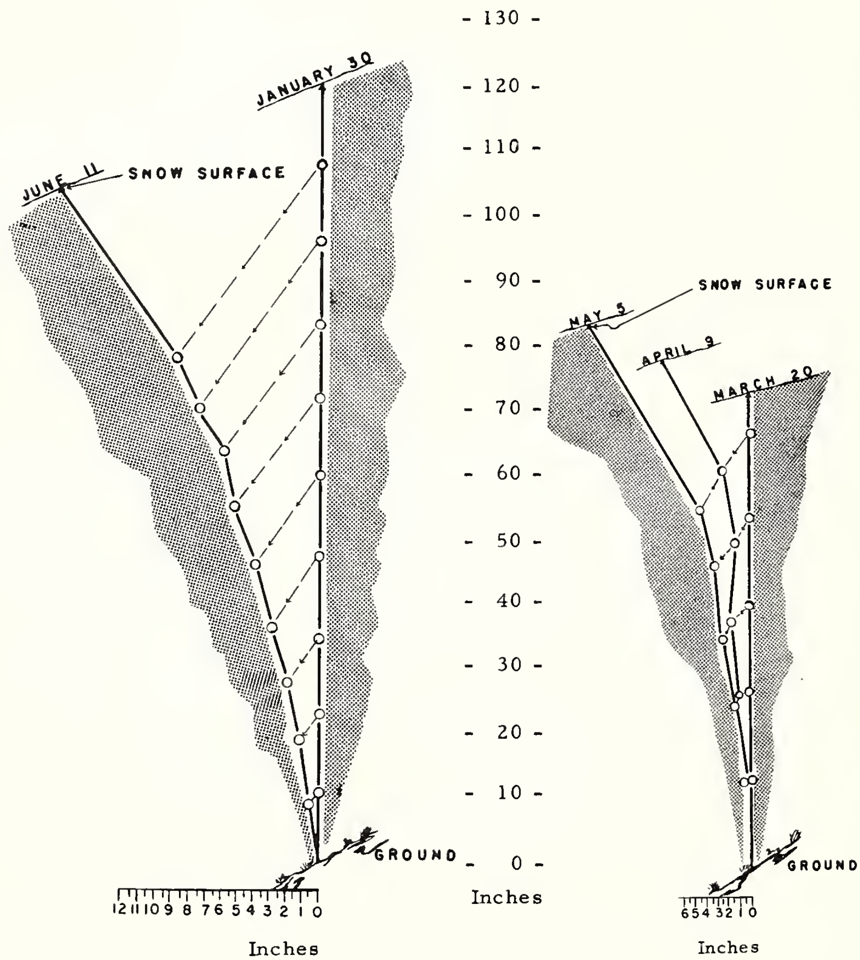


Figure W-2.--Table tennis balls placed in undisturbed snow at 1-foot intervals trace the movement of an alpine snowpack. Both creep, the downslope movement shown by the horizontal scale, and settlement, the shrinking movement shown in the vertical scale, were measured in two pits dug in the pack. Note that the scale on the horizontal axis for pit 2 is reduced.

Effect of wind direction on snow accumulation in forests is under study

Figure W-3.--
Wind-driven snow accumulated on the west side of an Engelmann spruce snag and on the foliage of live trees on the west slope of the Sangre de Cristo Mountains of northern New Mexico. Wind direction and snow movement are being studied to determine the role of forest in snow accumulation.

Increased streamflow continues from the White River in Colorado

There has been a great deal of interest in the effects of the "bug kill" areas of spruce on water yields and on watershed conditions in Colorado. A severe outbreak of the Engelmann spruce beetle began on the White River drainage in 1941 and continued through 1946. The outbreak covered 226 square miles of the forested area within the White River drainage. On the average, dead trees occupy 60 percent of the area.

An analysis was made to determine whether defoliation of the spruce cover caused a change in streamflow. Comparisons made between the mean annual streamflow before the Engelmann spruce beetle outbreak (1937-46 water years) and the mean annual streamflow after the beetle outbreak (1947-51 water years) were reported in 1955 and indicated an average increase of 22 percent. Control was provided by the annual flows of the Elk River (206-square-mile drainage) where no outbreak of the spruce beetle occurred. Water content of the snowpack on each of the watersheds on April 1 was also compared.

Adding seven additional water years to the original data and rerunning the analysis, we find that streamflow increases have stayed about the same. The mean annual streamflow after the beetle outbreak (1947-58 water years) appears to be increased about 25 percent. Most of the increased flow reaches the stream during the snow melting period and causes larger peak discharge rates.

This analysis is reported to show that streamflow is influenced by changes in forest cover. However, the Engelmann spruce bark beetle is not considered an efficient tool for watershed management research. Forest managers by planned control of plant species and density can more effectively achieve watershed management objectives without the tragic loss of timber resources, increased danger from snag-fed forest fires, and risk of erosion caused by the beetle outbreak.

Gully erosion stopped by proper location of structures

The location of structures is important in controlling gullies. This was shown by an evaluation of early gully-control structures installed on the Pike and San Isabel National Forests in Colorado. Gullies were classified into continuous and discontinuous channels. A continuous gully, one whose channel slope approaches the grade of the original valley floor, has one "critical" location (fig. W-4). A discontinuous gully, one characterized by (1) pronounced headcuts in the valley floor that mark the beginnings of individual gullies; (2) rapidly decreasing channel depth downstream; and (3) a fan of sediment deposits at the gully mouth, has several "critical" locations (fig. W-5).

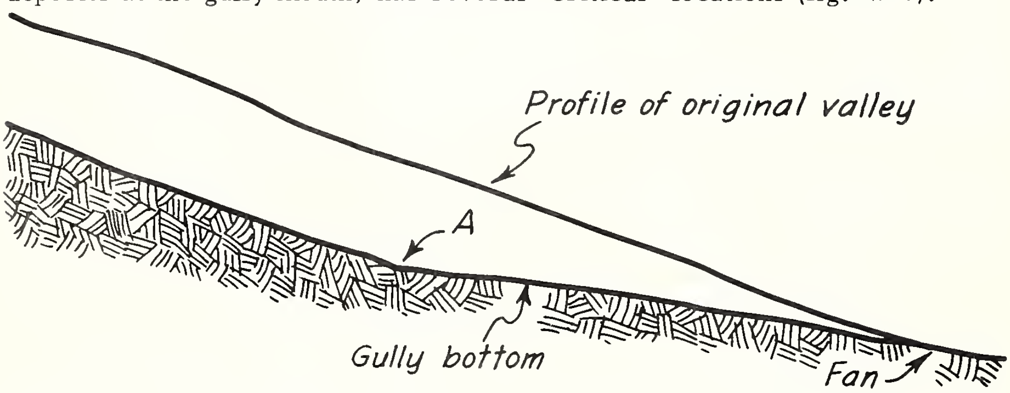


Figure W-4. --A longitudinal profile showing the main critical location (point A) in the lower segment of a continuous gully. Unless a control structure is installed at point A, pronounced changes of the channel base level will take place upstream from point A.

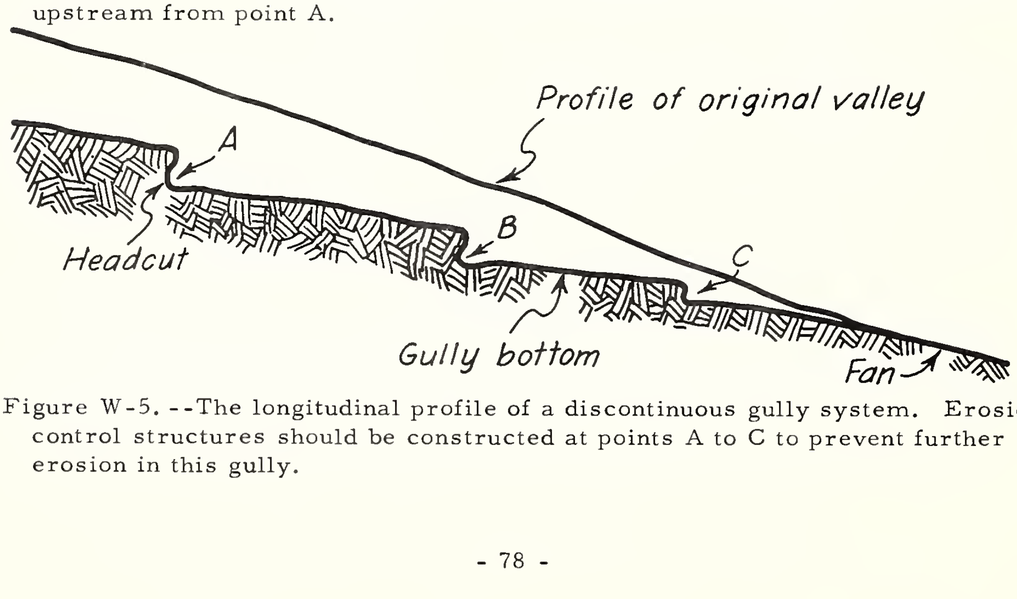


Figure W-5. --The longitudinal profile of a discontinuous gully system. Erosion-control structures should be constructed at points A to C to prevent further erosion in this gully.

Beaver Creek Evaluation Project in Arizona

The Beaver Creek Evaluation Project is a test of intensive multiple-use land management in Arizona. The project's objectives are to evaluate the effects of land treatments on water yield. The evaluation will include the physical and economic values of water, wildlife, timber, and recreation.

Beaver Creek drainage is on the Coconino National Forest and has a cover of ponderosa pine, alligator and Utah junipers, and semidesert vegetation. Fourteen small watersheds (100 to 2,000 acres) in the pine and juniper types as well as three large watersheds (up to 100,000 acres) are now being gaged for water yield. Some of the watersheds will be treated in various ways to change the plant cover. Treatments will include conversion to grass, intensive timber management, prescribed fire use, juniper eradication (fig. W-6) and range seeding in the woodland types.

Figure W-6. --Aerial view of the Beaver Creek Project on the Coconino National Forest in Arizona showing areas of juniper removal in foreground and topography of pine type in the background. Stringers of pine extend down into the juniper type. The area is providing the physical and economic data necessary for an evaluation of multiple-use land management.

Sediment movement excessive after wildfire in chaparral

Sediment production measured on small unburned chaparral watersheds is generally low. On the 3-Bar watersheds near Roosevelt, Arizona, only negligible amounts of sediment were trapped during the period January 1957 to June 1959 (table W-1). In contrast, since the nearly complete destruction of aerial plant cover by wildfire on the watersheds in June 1959, large quantities of sediment have been trapped at each of two watersheds (fig. W-7). At watershed B total sediment yield since August 1959 has exceeded 39,000 tons per square mile.

Tests now underway compare sediment yields from small watersheds seeded to lovegrass and sprayed to control shrubs with watersheds seeded and unsprayed and with other watersheds where no seeding was done. This will help determine the effectiveness of seeding and shrub control as management tools.

Table W-1.--Precipitation and sediment yields before and after wildfire on the 3-Bar chaparral watersheds, Roosevelt, Arizona

Date of storm		Total precipitation	Amount precipitation at maximum intensity rate	Maximum intensity rate	Sediment yield	
					Watershed B	Watershed C
		Inches	Inches	Inches/hr.	Tons per square mile	
			BEFORE FIRE			
1957:	January 7-10	8.61	0.70	0.70	0	50
	August 13	1.14	.86	2.58		
1958:	August 4	1.76	1.46	2.50	0	0
	August 6	1.25	1.25	3.00	0	0
	September 12	.69	.64	2.56	0	0
	Total sediment yield, May 1956 to July 1959				0	50
			AFTER FIRE			
1959:	August 4	2.15	2.00	2.40	8,629	3,607
	August 11	.76	.58	.87		
	August 22	.99	.94	2.45	13,822	3,227
	August 24	2.13	.68	2.72		
	October 29-30	7.11	1.18	.83	13,413	6,374
	December 9-14	[1] 2.85			0	795
	December 24-25	6.71	.52	2.08	3,760	4,342
1960:	January 11-13	3.62	--	Low	0	460
	March 1	1.17	--	Low	0	26
	Total sediment yield, August 1959 to March 1960				39,624	18,831

[1] Total of four separate storms.

Figure W-7. --Wildfire followed by rains caused heavy soil losses on chaparral watersheds north of Roosevelt, Arizona. Beginning with a high-intensity storm on August 4, 1959, 12 storms have produced measurable sediment yields from the granitic soils of the watersheds. On this 36-acre watershed, sediment in this debris basin amounted to 39,000 tons per square mile. On an adjacent 77-acre watershed 18,000 tons per square mile was measured during the 9-month period ending March 1960.

Intensive site treatment stops erosion

The removal of shrubs and the successful seeding to perennial grasses have effectively checked soil movement on the highly erodible granitic slopes in the transition from semidesert shrub to chaparral vegetation types near Roosevelt, Arizona.

Protection from grazing during the period 1925-53 did not significantly reduce erosion. Mechanical stabilization of soil, but with no change in plant cover, reduced sediment from 6,476 to 479 tons per square mile. Intensive site treatment involving grubbing of the shrubs, sloping of gully banks, mulching of the soil surface, and seeding to Boer and Lehmann lovegrasses, reduced sediment yields to an average of 15 tons per square mile during the period 1954-59. This was approximately 1 percent of the rate for untreated watersheds (table W-2).

Table W-2.--Soil loss as affected by changing from shrubby to perennial grass cover, Summit watersheds, Arizona

Treatment by individual watershed	Summer soil loss							
	Average 1931-41	Average 1954-59	1954	1955	1956	1957	1958	1959
	Tons per square mile							
Shrub removal and seeding, 1953	3,144	11	14	35	17	[1]T	T	T
Shrub removal and seeding, 1953	1,792	15	52	26	13	T	T	T
Shrub removal and seeding, 1953	3,060	18	60	30	15	T	T	T
Shrub removal and seeding, 1953	4,212	16	52	32	13	T	T	T
Original cover	6,281	570	1,220	1,447	338	333	T	83
Original cover	4,538	3,397	6,100	3,401	836	6,442	1,859	1,742

[1] Trace

Badger Wash cooperative study

In western Colorado, on highly erosive soils, a joint study to curtail runoff and erosion was started in 1953. At Badger Wash, the U. S. Geological Survey, U. S. Bureau of Reclamation, and U. S. Bureau of Land Management are working closely with the station in an effort to find out what changes in sediment yields, infiltration rates, and erosion rates can be expected from protecting areas from livestock grazing. A mechanical erosion-control program using small reservoirs is also underway. Initial infiltration rates are showing changes associated with protection from grazing. The amount of water applied prior to the start of runoff increased over a 5-year period from 0.17 inch to 0.28 inch on the ungrazed plots (fig. W-8).

Tamarisk cuttings are vigorous sprouters

Tamarisk, a plant growing on moist areas or along water channels is being studied to determine how it might be controlled. One control method, "root plowing," is effective so long as plants are cut below the root collar. Roots do not sprout but stems do. A study of the sprouting ability of the plant showed that all stem cuttings planted under the conditions of the experiment (table W-3) sprouted. Sprouting was most rapid in warm weather. Cuttings placed in an unheated greenhouse in November stayed dormant through the winter but sprouted 3 to 4 months after they were planted. Where sediment deposits have buried stems deeply, root plowing may not be effective.

Figure W-8. --Rocky Mountain infiltrometer in operation at Badger Wash in the salt desert type near Grand Junction, Colorado. Tests for the effects of livestock exclusion on infiltration are made on mixed soils derived from Mancos shale. The initial water-absorbing capacity of ungrazed plots increased significantly from 0.17 inch in 1953 to 0.28 inch in 1958. Grazed plots remained essentially the same, changing from 0.18 inch in 1953 to 0.21 inch in 1958. The amount of water applied to the plots prior to the start of runoff was used as a measure of initial water absorption.

Table W-3.--Sprouting of tamarisk stem cuttings. Cuttings were 8 inches long and 1 inch in diameter and planted in moist soil in a warm greenhouse

Month	Weeks after planting					
	4	8	12	16	20	24
			Percent with sprouts			
June	100					
July	100					
August	75	100				
September	90	100				
October	75	95	100			
November	38	85	90	98	98	100
November[1]	0	5	40	80	100	
December	15	70	90	95	100	
January	58	100				
February	85	100				
March	95	100				
April	100					

[1] Planted cuttings placed in unheated greenhouse.

Special glands remove salt from tamarisk

A knowledge of physiological features of tamarisk may help in finding more effective means of controlling the plant. One such feature is the plant's ability to secrete salt (fig. W-9). Understanding this process may provide clues on how to effectively poison the plant.

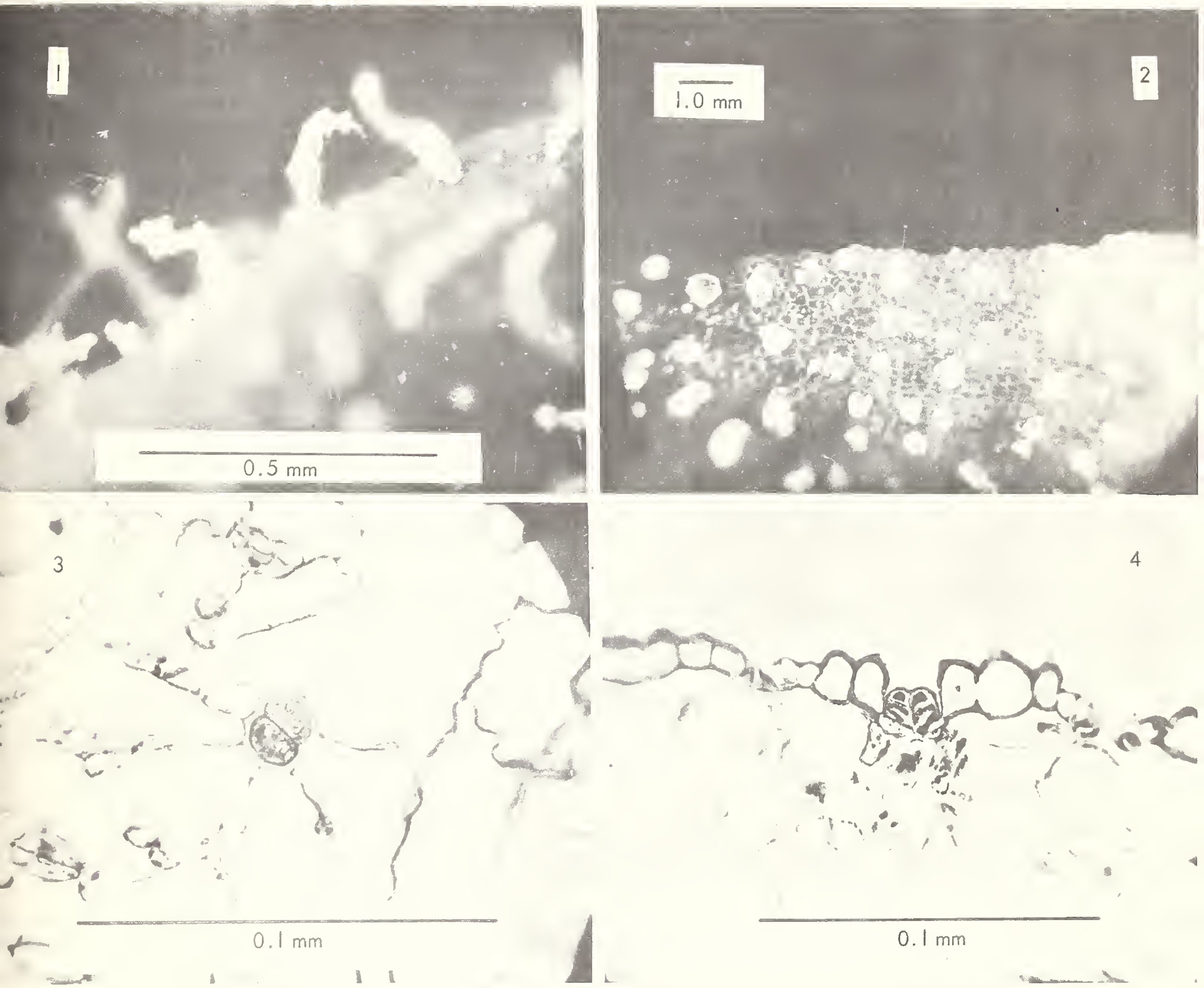


Figure W-9.--Foliage and small twigs of tamarisk are often covered with salty white bloom--giving rise to the common name of saltcedar. Microphotographs of the leaf shows the salt appears first as delicate whiskerlike columns (1). These deliquesce during periods of high humidity. Upon recrystallizing they become much coarser cuboids (2). Each whisker arises from a salt gland similar to that shown in horizontal section (3), and in vertical section (4). Internal mechanics of how the gland operates is under study.

Evapotranspiration rates
of Bermudagrass and
a tamarisk plant

Fig. W-10, no reduc., p. 86

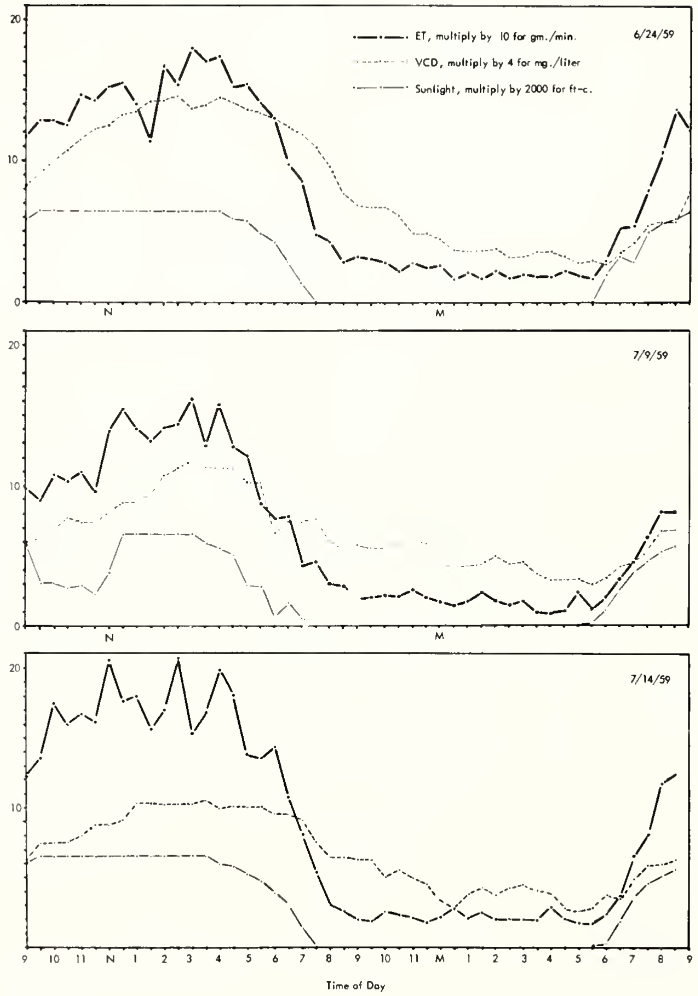


Figure W-10.--Daily course of water use (ET) from a plot containing mowed Bermudagrass and one large tamarisk shrub about 10 feet high were determined experimentally. The plot was enclosed in a transparent, inflatable tent that was ventilated at a known rate. Evapotranspiration losses were measured with an infrared gas analyzer. Vapor pressure deficit (VCD) and sunlight intensity were measured to explain variations in water use. Rate oscillations between 11:30 a.m. and 5:00 p.m. of July 14 suggest that the shrub may have wilted slightly and recovered several times under a heavy transpirational stress.

Publications

FOREST INSECT RESEARCH

Bennett, William H., and Ostmark, H. Eugene.
The truth about tessie terebrans. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 174, 16 pp., illus. [Processed.]

A popular cartoon-type booklet that describes the black turpentine beetle.

Knight, Fred B.
Measurement of Engelmann spruce beetle populations. Ecology 41: 249-252, illus.

Discusses the development of a method for sampling populations of the Engelmann spruce beetle and the application of the method to infestation-trend surveys.

______ Sequential sampling of Black Hills beetle populations. Res. Note 48, 8 pp., illus. [Processed.]

The sequential analysis technique is discussed and applied to sampling data for the Black Hills beetle. Sequential tables are presented for use in evaluations of Black Hills beetle infestations.

______ Sequential sampling of Engelmann spruce beetle infestations in standing trees. Res. Note 47, 4 pp., illus. [Processed.]

Sequential sampling plans are presented for use in evaluations of beetle populations in infested standing Engelmann spruce. Two sampling dates are included.

Massey, Calvin L.
DDT, a preventive control for the southwestern pine beetle. Res. Note 40, 1 pp. [Processed.]

Brief evaluation of DDT in a 2-percent emulsion as a control for the southwestern pine beetle in individual trees of high ornamental or recreational value.

____
Nematode parasites and associates of the California five-spined engraver, _Ips confusus_ (Lec.). Helminthol. Soc. Wash. Proc. 27: 14-22, illus.

Technical descriptions of three endoparasites and their effects on the host. Detailed line drawings.

____
A new species of nematoda, _Cylindrocorpus erectus_, associated with _Scolytus multistriatus_ Marsh. in American elm. Helminthol. Soc. Wash. Proc. 27: 42-44, illus.

Describes a new species of nematode. Detailed line drawings.

_______ and Pierce, Donald A.
Trirhabda nitidicollis, a pest of rabbitbrush in New Mexico. Jour. Range Mangt. 13: 216-217, illus.

Trirhabda nitidicollis Lec. may be an important factor in the ecology of rabbitbrush in the Southwest. It is possible that the insect could be manipulated to control rabbitbrush in areas where the plant is considered a noxious weed.

Ostmark, H. Eugene, and Massey, Calvin L.
Protect your pines from bark beetles. Sta. Paper 52, 19 pp., illus. [Processed.]

Illustrated with cartoon drawings, pictorially describes practical methods to be used in protecting trees of high ornamental or recreational value from attacks by bark beetles.

Wilford, B. H.
Forest-insect surveys in the central Rocky Mountains. Jour. Econ. Ent. 53: 458-462, illus.

Describes and discusses methods used in forest-insect surveys. Illustrates methods by hypothetical examples.

FOREST DISEASE RESEARCH

Andrews, Stuart R., and Daniels, John P.
A survey of dwarfmistletoe in Arizona and New Mexico. Sta. Paper 49, 17 pp., illus. [Processed.]

The survey showed that dwarfmistletoes are present in about 36 percent of the ponderosa pine type and about 47 percent of the stands classified as Douglas-fir. Annual mortality losses are estimated at 55 to 75 million board feet of ponderosa pine and 20 to 27 million feet in Douglas-fir.

_______ and Eslyn, Wallace E.
Sooty-bark canker of aspen in New Mexico. U. S. Agr. Res. Serv., Plant Dis. Rptr. 44: 373. [Processed.]

Records the occurrence of sooty-bark canker (Cenangium singulare (Rehm.)) Davidson and Cash on Chuska Mountain on the Navajo Reservation and Elk Mountain on the Santa Fe National Forest.

Hawksworth, Frank G.
Distribution of ponderosa pine dwarfmistletoe in the vicinity of an Arizona volcano. Ecology 41: 799-800.

Only about 1 percent of the pine stands in the vicinity of Sunset Crater were infected by dwarfmistletoe. Infection on an adjacent area was 37 percent.

____
Growth rate of dwarfmistletoe infections in relation to the crown class of the host. Res. Note 41, 4 pp., illus. [Processed.]

Dwarfmistletoes of ponderosa pine and lodgepole pine develop most rapidly in vigorously growing hosts. Growth rate of infections in dominants was nearly twice that in suppressed trees.

_______ and Gill, Lake S.
Rate of spread of dwarfmistletoe in ponderosa pine in the Southwest. Res. Note 42, 2 pp., illus. [Processed.]

Illustrates, with a colored diagram, spread of dwarfmistletoe. In 90 years, infection from a single overstory tree will cover about 2/3 acre in young dense stands and about 1-1/4 acres in open stands.

_______ and Hinds, Thomas E.
Cytospora canker of Engelmann spruce in Colorado. U. S. Agr. Res. Serv., Plant Dis. Rptr. 44: 72. [Processed.]

Cytospora canker is reported for the first time on Engelmann spruce. It appears to be of little importance on this host.

Hinds, Thomas E., Hawksworth, Frank G., and Davidson, Ross W.
Decay of subalpine fir in Colorado. Sta. Paper 51, 13 pp., illus. [Processed.]

Decay in 319 trees averaged 35 percent (board foot basis). *Stereum sanguinolentum* was by far the most important decay fungus in subalpine fir.

McNabb, Harold S. Jr., Edgren, J. W., and Eslyn, W. E.
Pathological and normal heartwood in hardwoods (Abstract). IX Internatl. Bot. Cong. Proc. 2: 244-245.

Observed similarities between normal and pathological heartwood in hardwoods suggest a means for obtaining and studying heartwood formation in young trees.

Peterson, Glenn W., Nuland, David, and Weihing, John L.
Test of four fungicides for control of cedar blight. U. S. Agr. Res. Serv., Plant Dis. Rptr. 44: 744-746. [Processed.]

Reports superior control of Phomopsis-blight of eastern redcedar seedlings (1-0 and 2-0) obtained with the fungicide, Puratized Agricultural Spray, in an eastern Nebraska nursery.

Peterson, Roger S.
Development of western gall rust in lodgepole pine. Phytopathology 50: 876-881, illus.

Correlates the growth rate of western gall rust with vigor of its pine hosts, and describes changes in pine wood, resulting in weakening, due to rust infection.

______
Western gall rust on hard pines. U. S. Dept. Agr. Forest Pest Leaflet 50, 8 pp., illus.

Describes western gall rust and damage caused by this rust on two- and three-needled pines, and suggests control measures.

FOREST MANAGEMENT AND FOREST FIRE RESEARCH

Alexander, Robert R.
Thinning lodgepole pine in the central Rocky Mountains. Jour. Forestry 58: 99-104, illus.

With a market for small-sized material and only one precommercial thinning possible, thinning to 600, 500, and 400 trees per acre is recommended when initial diameters are 1.0 to 2.0, 3.0, and 4.0 inches, respectively. For stands averaging 5.0 inches or more in diameter, a light commercial thinning leaving 300 trees per acre may be possible in the future.

Bagley, Walter T., and Read, Ralph A.
Some temperature and photoperiod effects on growth of eastern redcedar seedlings. Iowa State Col. Jour. Sci. 34 (4): 595-602, illus. [Processed.]

Discusses relationships of day and night temperatures to length of photoperiod as important factors in determining the practicability of utilizing supplemental light to stimulate growth of tree seedlings in the nursery.

Gaines, Edward M., and Peterson, Geraldine.
Cubic-foot volume tables for southwestern ponderosa pine. Sta. Paper 50, 15 pp. [Processed.]

Tables are inside bark, are separate for young growth and old growth and for volume to 4.0-inch and 8.0-inch d.i.b. tops, and are based on total heights to 4.0-inch and 8.0-inch d.i.b. tops. A method for converting cubic feet to cords is presented.

Halls, L. K., Read, R. A., and Crawford, H. S., Jr.
Forage and ground-cover conditions in unmanaged Ozark forests. South. Forest Res. 1: 1-6, illus.

Presents results of a 10-year study of the effects of minimal grazing and control of fire on unmanaged forests in northern Arkansas.

Larson, M. M.
Frost heaving influences drought-hardiness of ponderosa pine seedlings. Res. Note 45, 2 pp. [Processed.]

Presents results of an observational study of 261 natural seedlings at the Fort Valley Experimental Forest in Arizona in 1956.

Lindenmuth, A. W., Jr.
A survey of effects of intentional burning on fuels and timber stands of ponderosa pine in Arizona. Sta. Paper 54, 22 pp., illus. [Processed.]

A detailed report of benefits and damages as related to stand condition, potential fire intensity, actual fire intensity, [illegible] and density, and tree size, based on 6,[illegible]66 observation points systematically distributed in a 27,000-acre intentionally burned area, showing, in general, a low ratio of benefits to damages.

Minor, Charles O.
Estimating tree diameters of Arizona ponderosa pine from aerial photographs. Res. Note 46, 2 pp., illus. [Processed.]

Presents and discusses equations for estimating tree diameters based on crown diameters and total heights scaled from aerial photographs.

Myers, Clifford A.
Estimating oven-dry weight of pulpwood in standing ponderosa pines. Jour. Forestry 58: 889-891, illus.

Oven-dry weights of the merchantable boles and their cubic-foot volumes were closely correlated. Weights can be computed from cubic-foot volumes or from tree diameters and merchantable lengths.

_______ and Van Deusen, James L.
Merchantable cubic-foot volume table for immature Black Hills ponderosa pine. Res. Note 44, 2 pp. [Processed.]

Presents cubic-foot volumes above the stump to the point where stem diameter inside bark is 4.0 inches for trees 5 to 21 inches d.b.h. and 20 to 110 feet tall.

_______ and Van Deusen, James L.
Natural thinning of ponderosa pine in the Black Hills. Jour. Forestry 58: 962-964, illus.

Natural thinning will not prevent stagnation of dense young stands of ponderosa pine in the Black Hills. Precommercial thinning will be necessary if dense young stands are to produce salable products on a reasonable rotation. Stagnated stands will respond to release up to at least age 40.

_______ and Van Deusen, James L.
Site index of ponderosa pine in the Black Hills from soil and topography. Jour. Forestry 58: 548-551, 554-555, illus.

Site index can be estimated from soil depth, aspect, gradient, and slope position. Presents equations and tables for determining site index from these factors.

Shaw, Elmer W.
Windbreaks are worth the worry. West. Farm Life 62(4): 4, illus.

A popular article outlining some of the advantages of windbreaks; also the problems.

FOREST BIOLOGY

Reid, Vincent H.
Too hot for Bob. Texas Game and Fish 18(11): 20-21, illus.

Reviews studies from four States which show a relationship of the size of the annual quail crop with summer rainfall or temperature.

_______ and Goodrum, P. D.
Bobwhite quail: a product of longleaf pine forests. North Amer. Wildlife and Nat. Resources Conf. Trans. 25: 241-252, illus.

Reports 10-year findings on annual quail production and resulting winter populations and the relationship between these figures and those of summer temperatures and rainfall for an area in the southwestern portion of the longleaf pine belt.

FOREST UTILIZATION RESEARCH

Boldt, C. E., and Arbogast, Carl, Jr.
Charcoal kiln operation for improved timber stands.
Forest Products Jour. 10(1): 42-44.

Analyzes cost of producing charcoal in a 7-cord masonry kiln in Michigan's Upper Peninsula, using roundwood from partial cuts in second-growth northern hardwood stands.

Herman, Francis R.
A test of skyline cable logging on steep slopes--a progress report.
Sta. Paper 53, 17 pp., illus. [Processed.]

The systems offer promise for logging steep sites in the central Rocky Mountains. Costs of a Wyssen skyline-crane test operation near Fraser, Colorado, were high, but not unfavorable when the advantages over conventional systems were considered.

Woodfin, Richard O., Jr.
Taper in Black Hills ponderosa pine sawtimber trees.
Res. Note 52, 3 pp. [Processed.]

Gives small-end log diameters for 8- and 16-foot long logs from Black Hills ponderosa pine sawtimber trees of various diameters and heights.

_______ and Landt, E. F.
Conversion of cubic-foot volumes of Black Hills ponderosa pine to cords.
Res. Note 31 (revised), 2 pp. [Processed.]

Factors given for converting cubic-foot volumes based on (1) total tree height, and (2) merchantable tree height to merchantable rough and peeled cords.

FOREST ECONOMICS RESEARCH

Miller, Robert L., and Southern, John H.
Management intent of small timberland owners in East Texas. Texas Agr. Expt. Sta. MP 439, 7 pp., illus.

Presents graphically some of the characteristics of small private land ownerships (21 to 5,000 acres).

_______ and Wilson, Alvin K.
Log production in Colorado and Wyoming, 1957. Forest Survey Release 3, 6 pp., illus. [Processed.]

Reports production of 315 million board feet (Int. 1/4-inch rule) of saw logs in Colorado and Wyoming in 1957, with detailed data on production by land ownership, county, species, and live and dead trees.

Colorado Cooperative Pocket Gopher Project.
Pocket gophers in Colorado. Colo. Agr. Expt. Sta. Bul. 508-S, 26 pp., illus.

A report on the pocket gophers found in Colorado including descriptions of the biology, habits, and control of the animals.

Klipple, G. E., and Costello, David F.
Vegetation and cattle response to different intensities of grazing on short-grass range on the central Great Plains. U. S. Dept. Agr. Tech. Bul. 1216, 82 pp., illus.

Response of range vegetation of the short-grass association to three intensities of herbage utilization during the growing seasons and the response of the yearling beef cattle that did the grazing were reported, analyzed, and evaluated for a 13-year period (1940-52). A proper-use factor was suggested for short-grass vegetation when grazed only during the growing season. Recommendations for the grazing management of range vegetation of this plant association were made.

May, Morton.
Key to the major grasses of the Big Horn Mountains based on vegetative characters. Wyo. Univ. Agr. Expt. Sta. Bul. 371, 44 pp., illus.

Presents a simple, usable key based entirely on vegetative characters for use when flowering parts are not available. Following a discussion of the vegetative characters of grasses, and the vegetative key, are detailed vegetative descriptions of the 68 major grass species of the Big Horn Mountains and their common habitats. Taxonomic terminology has been kept to a minimum.

____
Production and forage preference on subalpine sheep ranges of the Bighorn National Forest. Res. Note 53, 8 pp., illus. [Processed.]

Reports production, utilization, and relative importance of forbs, grass, and grasslike plants as shown by studies made in 1956 and 1957 on sheep ranges.

Paulsen, Harold A., Jr.
Plant cover and forage use of alpine sheep ranges in the central Rocky Mountains. Iowa State Col. Jour. Sci. 34(4): 731-748, illus. [Processed.]

An extensive survey of alpine range areas in Colorado, Wyoming, and northern New Mexico during two successive summers furnished information on the gross characteristics of the vegetation and how it is grazed by bands of domestic sheep.

_______ and Ares, Fred N.
Long-term trends in cattle and forage on an arid southwestern range (Abstract). Amer. Soc. Range Mangt. Proc. 13: 45-46.

Summarizes long-term vegetation records on the Jornada Experimental Range in southern New Mexico. Density of black grama during dry periods was reduced to about the same minimum irrespective of degree of grazing, but recovery was greatest when use was 40 percent or less. Yearly fluctuations in production were up to fourteenfold, depending on the precipitation during the preceding 15 months from July through September. Tobosa showed about the same response but could be used up to 55 percent.

Pond, Floyd W.
Vigor of Idaho fescue in relation to different grazing intensities. Jour. Range Mangt. 13: 28-30.

Discusses the effects of three degrees of cattle grazing on Idaho fescue growing on two soils. These studies were located in the Big Horn Mountains of Wyoming.

_______ and Cable, Dwight R.
Effect of heat treatment on sprout production of some shrubs of the chaparral in central Arizona. Jour. Range Mangt. 13: 313-317, illus.

Presents results of burning seven species of chaparral with a hand torch at intervals varying from 1 to 5 years.

Reid, Elbert H., and Price, Raymond.
American Forestry: Six decades of growth. Chapter 8, Progress in forest-range management. pp. 112-122. Washington, D. C.

Discusses the development of range management as a science and art since its beginning about 1900 to 1960. Also suggests the outlook for range management in the years ahead.

Reynolds, Hudson G.
Life history notes on Merriam's kangaroo rat in southern Arizona. Jour. Mammal. 41: 48-58.

Some aspects of reproduction, development, breeding habits, activity patterns, and home range are analyzed and discussed.

____
Review of "Grass Productivity" by Andre Voison. Jour. Range Mangt. 13: 155.

A technical book review.

Smith, Dixie R., and May, Morton.
Comparison of rotation and season-long summer grazing on subalpine range in Wyoming (Progress Report). Wyo. Univ. Mimeo. Cir. 128, 6 pp. [Processed.]

Gives first-year results of a comparison of summerlong grazing at a moderate stocking rate with rotation grazing at a moderate rate and a heavy rate.

_______, May, Morton, Johnson, W. M., and Stratton, Paul.
Comparison of rotation and season-long summer grazing on subalpine range in Wyoming (Progress Report). Wyo. Univ. Mimeo. Cir. 137, 3 pp. [Processed.]

A progress report covering utilization, uniformity of grazing use, and cattle gains as related to treatments during the 1959-60 grazing season.

Smith, Dwight R., and Love, L. D.
Moderate grazing grows fatter cattle. Colo. Rancher and Farmer 14(2): 5, illus.

Reports 18 years of research on a bunchgrass range in ponderosa pine country of the Rocky Mountains. Recommends moderate grazing, 30 to 40 percent removal of desirable grasses and sedge, as the optimum grazing intensity for maintaining forage and cattle production.

Springfield, H. W.
Shrub use by sheep on seeded range. Res. Note 49, 4 pp., illus. [Processed.]

Describes heavy utilization of sagebrush and rabbitbrush by sheep during spring lambing on crested wheatgrass and gives explanations why shrubs were heavily grazed.

Tschirley, Fred H., and Martin, S. Clark.
Germination and longevity of velvet mesquite seed in soil. Jour. Range Mangt. 13: 94-97, illus.

Seeds of velvet mesquite were still able to germinate after 10 years in the soil. Germination of hulled seeds was 15.8 percent; of seeds in pods, 44.7 percent.

Turner, George T.
A lay-down fence for snow country. Jour. Range Mangt. 13: 43-44, illus.

Describes construction of a four-wire fence that can be let down as a unit while still under tension. Lying on the ground during the winter, wires escape damage from the settling snowpack.

[Reproduced in Colo. Rancher & Farmer 14 (9): 7, illus.
Amer. Cattle Prod. 42 (1): 14, illus.
Amer. Hereford Jour. 51(17): 124, illus.]

WATERSHED MANAGEMENT RESEARCH

Aldon, Earl F.
Research in the ponderosa pine type. In Watershed management research in Arizona, progress report, 1959. pp. 17-24, illus. [Processed.]

Basic field data on canopy interception, weight of the forest floor, and moisture content of the forest floor are presented for three pole-sized ponderosa pine areas in Arizona. Streamflow periods and sediment measurements taken on the Beaver Creek experimental watershed are also presented.

Berndt, Herbert W.
Precipitation and streamflow of a Colorado Front Range watershed. Sta. Paper 47, 14 pp., illus. [Processed.]

Discusses relations between precipitation and water yield for a small drainage heading in the Colorado Front Range ponderosa pine type.

____
Researcher writes on "how will" sagebrush affect watersheds? Wyo. Stockman Farmer 66 (4): 18, illus.

A brief description of a high-elevation sagebrush watershed study and report of the 1959 season.

Decker, John P., and Wien, Janet D.
Transpirational surges in Tamarix and Eucalyptus as measured with an infrared gas analyzer. Plant Phys. 35: 340-343, illus.

Describes an apparatus for continuous recording of transpiration rate of an intact leaf or twig. Reports rate changes under various experimental conditions.

Dortignac, E. J., and Love, L. D.
Relation of plant cover to infiltration and erosion in ponderosa pine forests of Colorado. Amer. Soc. Agr. Engin. Trans. 3(1): 58-61, illus.

Reports infiltration and erosion rates measured with the Rocky Mountain infiltrometer, a rainfall-simulator, on vegetation-soil conditions in the ponderosa pine forests of Colorado.

Gary, Howard L.
Utilization of five-stamen tamarisk by cattle. Res. Note 51, 4 pp., illus. [Processed.]

Cattle utilized significant amounts of tamarisk (saltcedar) sprout growth on study areas in Arizona.

Glendening, George E.
Research in the chaparral type. In Watershed management research in Arizona, progress report, 1959. pp. 33-43, illus. [Processed.]

Summarizes results of streamflow, sedimentation, and other studies started during the 1930's on Sierra Ancha experimental watersheds north of Globe, Arizona.

Heede, Burchard H.
Review of "Der Einfluss des Waldes und des Kahlschlages auf den Abfluss-vorgang, den Wasserhaushalt und den Bodenabtrag" [The influence of forests and clear-cut areas on streamflow, the hydrologic process and erosion] by J. Delfs, et al. Forest Science 6: 17-18.

Review of a technical book that covers results of the first 5 years of a forest hydrological study in the Oberharz (1948-53).

________ Review of "Grundlagen der Gruenverbauung" [The fundamentals of plant use for soil stabilization] by H. M. Schiechtl. Forest Science 6: 366-367.

Review of a technical book that covers results of 10 years' observation and experiments on the use of plants for soil stabilization.

________ A study of early gully-control structures in the Colorado Front Range. Sta. Paper 55, 42 pp., illus. [Processed.]

Describes characteristics of gully systems and evaluates effectiveness of control structures installed 25 years ago. Recommends simple check dams for future gully treatment.

Hoover, Marvin D.
Forest watershed research--some accomplishments and opportunities. Soc. Amer. Foresters Proc. 1959: 198-200.

Discusses major watershed research accomplishments and the future research opportunities to provide information needed for improvement of water yields and control of erosion. The need for investigations of energy exchange by individual species and stands, and of the biological controls over transpiration is emphasized.

________ Prospects for affecting the quantity and timing of water yield through snowpack management in southern Rocky Mountain area. West. Snow Conf. Proc. 1960: 51-53. [Processed.]

Results and implications of research on snow capture in the alpine zone and of the role of forests in the subalpine zone.

Horton, J. S.
Use of a root plow in clearing tamarisk stands. Res. Note 50, 6 pp., illus. [Processed.]

A root plow, such as made by Fleco Corporation, proved to be highly successful in clearing mature tamarisk stands when the soil was dry and the weather warm.

_______, Decker, John P., and Gary, Howard L.
Research in stream-bottom vegetation. In Watershed management research in Arizona, progress report, 1959. pp. 67-78, illus. [Processed.]

Summarizes recent research on the physiology and ecology of five-stamen tamarisk (saltcedar).

_______, Mounts, F. C., and Kraft, J. M.
Seed germination and seedling establishment of phreatophyte species. Sta. Paper 48, 26 pp., illus. [Processed.]

Fresh seed of five-stamen tamarisk germinates rapidly on saturated soils. Seedlings grow slowly and are very sensitive to drying.

Love, L. D., and Goodell, B. C.
Effects of forest logging on water yields. In Progress in watershed management. Ariz. State Land Dept. and Ariz. Water Res. Comm. Proc. 3: 111-115, illus. [Processed.]

Plot and watershed studies conducted at the Fraser Experimental Forest dealing with the effects of forest logging on water yield are briefly described. Indications are that water yield can be increased substantially by forest logging. The use of the skyline-crane in harvesting timber on slopes in excess of 50 percent is outlined.

_______ and Goodell, B. C.
Watershed research on the Fraser Experimental Forest. Jour. Forestry 58: 272-275, illus.

Twenty years of watershed research at the Fraser Experimental Forest is briefly described. The results of plot and watershed studies of the influence of timber harvesting on snow accumulation and melt, and on streamflow are summarized. The need for additional watershed research is outlined.

Martinelli, M. Jr.
Alpine snow research. Jour. Forestry 58: 278-281, illus.

Summarizes the alpine snow research carried out in Colorado for the past 5 years. Reports the work in progress and points out problems anticipated in future research.

———— A look at avalanche control structures in Europe. West. Snow Conf. Proc. 1960: 67-70, illus. [Processed.]

Three types of avalanche-control structures currently being used in Europe are described and illustrated.

———— Creep and settlement in an alpine snowpack. Res. Note 43, 44 pp., illus. [Processed.]

Total settlement was 2.6 times total creep in snowpacks 5 to 9 feet deep on short slopes with grades of 20 to 56 percent. For the period January 30 to June 11 total creep down the fall line was 0.72 inch per foot of snow depth; total settlement was 3.25 inches per foot of snow depth for the same period.

———— Moisture exchange between the atmosphere and alpine snow surfaces under summer conditions (preliminary results). Jour. Met. 17 (2): 227-231, illus.

Describes short-term studies of evaporation and condensation on snowfields in the Colorado Rockies. Traces diurnal trends and net gains.

Orr, Howard K.
Precipitation and streamflow in the Black Hills. Sta. Paper 44, 25 pp., illus. [Processed.] (Not listed in the station's 1959 annual report.)

Describes in detail the precipitation and streamflow of the Black Hills. Equations are developed for estimating runoff in inches using two factors: annual precipitation in inches and antecedent September-December precipitation in inches.

———— Soil porosity and bulk density on grazed and protected Kentucky bluegrass range in the Black Hills. Jour. Range Mangt. 13: 80-86, illus.

Reports measurements of soil porosity and bulk density inside exclosures and on grazed range at each of four bluegrass stream-bottom sites as related to soil compaction.

Reynolds, Hudson G.
Current watershed management research by the U. S. Forest Service in Arizona. In Progress in watershed management. Ariz. State Land Dept. and Ariz. Water Res. Comm. Proc. 3: 63-93, illus. [Processed.]

The need for better watershed management, problems involved, research program and some of the current findings of U. S. Forest Service watershed management research in Arizona are described and practical management implication are discussed.

———
Scope of current watershed management research in Arizona. In Watershed management research in Arizona, progress report, 1959. pp. 1-4, illus. [Processed.]

General characteristics and locations of the five major vegetational types and experimental areas for watershed management research in Arizona are outlined by maps and tabulations.

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Watershed management research in Arizona and New Mexico. Jour. Forestry 58: 275-278, illus.

Research by the U. S. Forest Service in Arizona and New Mexico is emphasizing water yields at the higher elevations, coordinating watershed with timber and range management at intermediate elevations, and reducing flood flow and sedimentation at the lower elevations. More intensive watershed management practices should result in a greater supply of water, timber, livestock, game, and recreation for an expanding population.

Rich, Lowell R.
Research in the mixed conifer type. In Watershed management research in Arizona, progress report, 1959. pp. 7-16, illus. [Processed.]

Describes research in mixed conifer type of Arizona being conducted at Workman Creek north of Roosevelt Lake and in the White Mountains near Springerville. Considers streamflow and plant cover changes on watersheds, soil-moisture uses on plots, and snow-mapping studies.

Skau, Clarence M.
Research in the pinyon-juniper type. In Watershed management research in Arizona, progress report, 1959. pp. 27-29, illus. [Processed.]

Summarizes relationship of interception and surface runoff to three stand-density classes of pinyon juniper.

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Kovner, J. L.
Discussion of "Hydrologic studies by electronic computers in TVA" by Willard M. Snyder. Hydraul. Div. Jour., Amer. Soc. Civil Engin. Proc. 86 (HY8): 67-68.

Comments on watershed management paper dealing with the effects of cultural treatment of vegetation on runoff.

Love, L. D.
The Fraser Experimental Forest. . its work and aims. Sta. Paper 8 (revised), 16 pp., illus. [Processed.]

This nontechnical publication describes the highlights of forest and watershed management research at the Fraser Experimental Forest during the past quarter century. Results of research are illustrated by means of photographs, charts, and diagrams.

Price, Raymond.
Progress in the integration of forestry and grazing. Paper presented at Fifth World Forestry Congress, Seattle, Washington, Aug. 29-Sept. 10. 15 pp. [Processed.]

Reviews progress in the United States and Canada in meeting problems of integration of forestry and grazing on forest and associated lands used by domestic livestock and wildlife, especially big game.

Shaw, Elmer W.
The editor's role as an interpreter.
Amer. Assoc. Agr. College Editors, April 1960 issue, p. 7.

Briefly describes a technical editor's various liaison roles and presents a challenge to fill these roles more effectively.

Station Staff.
Annual report, 1959. 100 pp., illus. [Processed.]

Outlines research progress at the station during 1959.